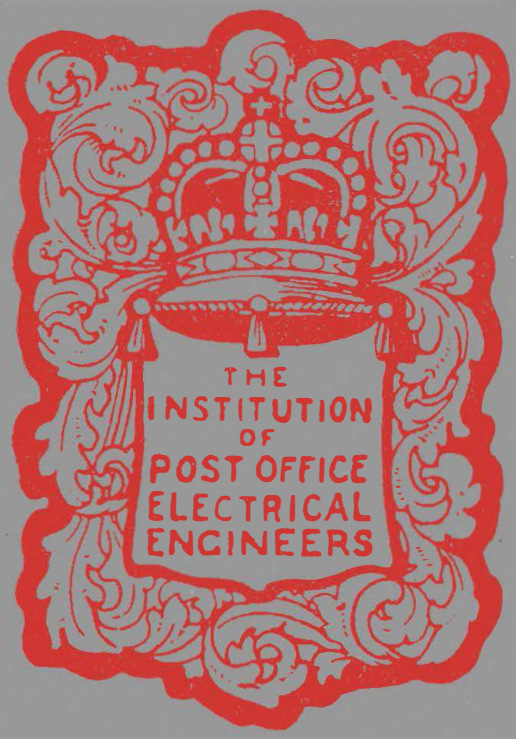
THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL



VOL. 19 PART I

APRIL 1926

Price 1/6 net.

ADVERTISEMENT INDEX
see page xii.

THE

LONDON ELECTRIC WIRE CO.
AND SMITHS, LTD.

Playhouse Yard, Golden Lane, London, E.C.1.

Telegrams: "Electric, London." Telephone: Clerkenwell 1388, 1389, 1390, 1391.

MANUFACTURERS OF

Every Description of Cables and Wires for Electrical Purposes.

Cotton-Covered and Braided Wires.
Cotton-Covered Strips and Cables.
Silk-Covered and Enamel Insulated Wires.
Multiple Cables.
Flexible Cords.
Cables and Flexibles for Wireless Work.

"Eureka," Nickelchrome and other High Resistance Wires.

Pitman's Books for Engineers and Students.

ELEMENTARY TELEGRAPHY.

By H. W. PENDRY. Second Edition. Specially written for candidates for C. & G. I. Examinations. 189 Illustrations. **7s. 6d.** net.

TELEGRAPHY.

By T. E. HERBERT, M.I.E.E., Assistant Superintending Engineer, Post Office Engineering Dept. A Detailed Exposition of the Telegraph System af the British Post Office. Fourth Edition. Revised and Enlarged. 1040 pages. 640 Illustrations. **18s.** net.

TELEPHONY.

By the same Author. This work contains full information regarding the Telephone Systems and Apparatus used by the British Post Office. 883 pages. 618 Illustrations. **18s.** net.

AUTOMATIC TELEPHONES.

By F. A. ELLSON, B.Sc. Hons. (Vict.), A.M.I.E.E., *Engineer, G.P.O.* An introductory treatise dealing with the fundamental principles, methods, and advantages of automatic telephony. 227 pages. 48 Illustrations. **5s.** net.

THE PRACTICAL TELEPHONE HANDBOOK AND GUIDE TO THE TELEPHONE EXCHANGE.

By JOSEPH POOLE, A.M.I.E.E., Wh.Sc. This book is recommended by the Examiners for the City and Guilds Institute Examinations in Telephony. Sixth Edition, 725 pages. 585 Illustrations. **15s.** net.

ARITHMETIC OF TELEGRAPHY AND TELEPHONY.

By T. E. HERBERT, M.I.E.E., and R. G. DE WARDT, *of the Post Office Engineering Department.* Suitable for candidates for City and Guilds Institute Grade I. Examination. 187 pages, 37 diagrams. **5s.** net.

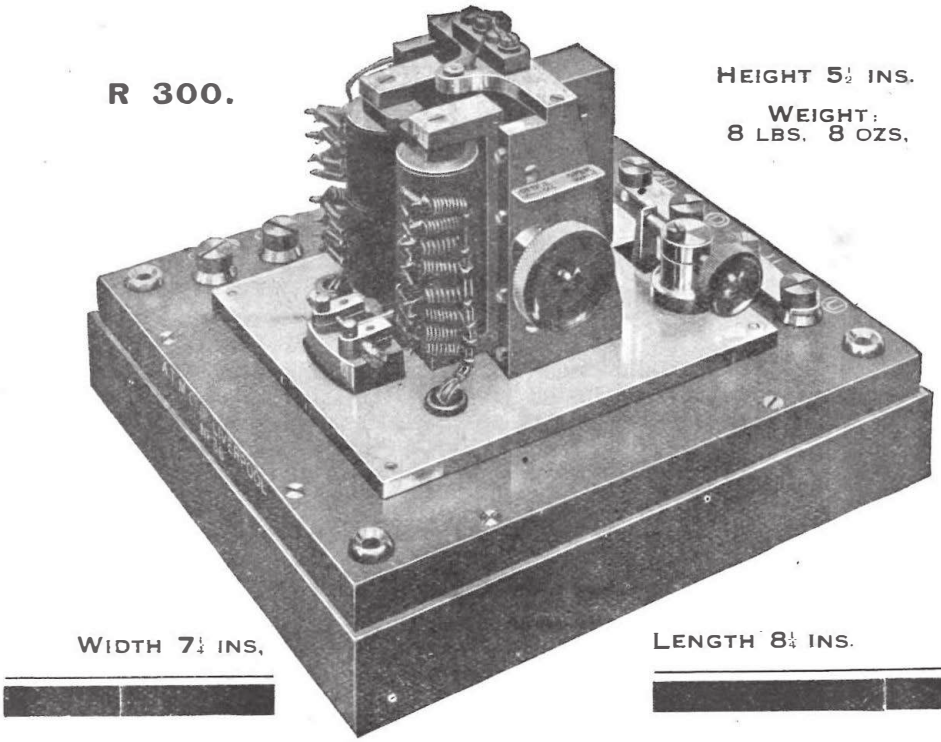
RADIO COMMUNICATION, MODERN.

By J. H. REYNER, B.Sc. (Hons.), A.C.G.I., D.I.C., *of the Post Office Engineering Dept.* A manual of modern theory and practice, covering the syllabus of the City and Guilds Examination and suitable for candidates for the P.M.G. certificate. Second Edition, thoroughly revised. 220 pages. 121 Illustrations **5s.** net.

THE BAUDOT PRINTING TELEGRAPH SYSTEM.

By H. W. PENDRY. Second Edition. With 72 illustrations of the latest models. **6s.** net.

Complete list post free: **PITMAN'S, Parker Street, Kingsway, W.C.2.**



A.T.M.

GULSTAD RELAY

CABLE PATTERN

THIS pattern relay has been developed for specially difficult lines and submarine cables.

The adjustment of the contact carriage and the relation of the electromagnet cores to the armature system is of wide range and can be made in minute steps.

The frame in which the coils slide is very rigid and the relay is not susceptible to extraneous vibations.

SEND TO-DAY
FOR
CATALOGUE
No. 39.

AUTOMATIC TELEPHONE MANUFACTURING CO., LTD.

Head Office and Works:

MILTON ROAD,
EDGE LANE,
LIVERPOOL.

London Office:

NORFOLK HOUSE,
NORFOLK STREET
STRAND, W.C.2

The Post Office Electrical Engineers' Journal.

A QUARTERLY JOURNAL.

CONTENTS FOR APRIL, 1926.

COPYRIGHT.—The entire contents of this Journal are covered by general copyright, and special permission is necessary for reprinting long extracts, but Editors are welcome to use not more than one third of any article, provided credit is given at the beginning or end thus: "From the 'Post Office Electrical Engineers' Journal.'"

	PAGE
UNDERGROUND TELEGRAPH CIRCUITS WORKED FROM UNIVERSAL BATTERIES	1
WAR OFFICE PNEUMATIC TUBE CENTRE—J. E. McGregor, A.C.G.I., A.M.I.E.E.	4
TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM	17
AUTOMATIC EXCHANGE DEVELOPMENT—J. Hedley, M.I.E.E.	18
LEEDS TELEPHONE AREA—H. W. Dipple, A.M.I.E.E.	22
TIME SAVING TESTERS—W. Prickett and H. S. Smith	38
GUILDHALL EXCHANGE TUNNEL	43
THE POST OFFICE WIRELESS SERVICES	58
THE CENTRAL RADIO OFFICE—A. Irwin	67
TRANSATLANTIC TELEPHONY—A. G. Lee, M.C., B.Sc., M.I.E.E.	74
NOTES AND COMMENTS	76
HEADQUARTERS NOTES	79
LONDON DISTRICT NOTES	82
THE INSTITUTION OF ELECTRICAL ENGINEERS	84
LOCAL CENTRE NOTES	84
RETIREMENT OF MR. T. E. P. STRETCHE	89
BOOK REVIEWS	94
STAFF CHANGES	97
COMMUNICATIONS	100

All communications with regard to advertisements to be addressed to:

The Advertisement Manager,
Post Office Electrical Engineers' Journal,
4, Ludgate Hill, London, E.C.4.

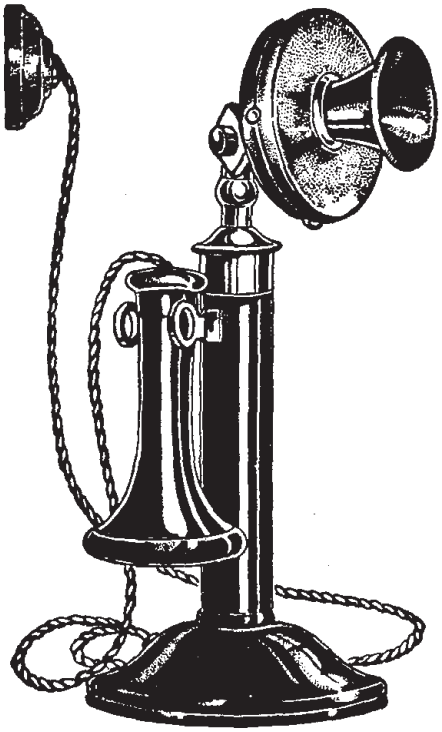
PUBLISHERS:

THE ELECTRICAL REVIEW, LTD., 4, LUDGATE HILL, E.C.

Price 1/6 net, post free, 1/9.

Annual Subscription, postage inclusive, 7/-, payable in advance.

Hindrance or Help —which?



IS the 'phone system you instal a blessing—or otherwise. Does *your* 'phone mumble its messages, connect wrong departments . . . occasionally go on strike altogether?

Better instal an **Ericsson** Telephone System. Its clear-speech, working-all-the-time efficiency, tiny repair bill—all will repay in repeat orders and goodwill.

We can help in your telephone problems Write us to-night for free illustrated list.

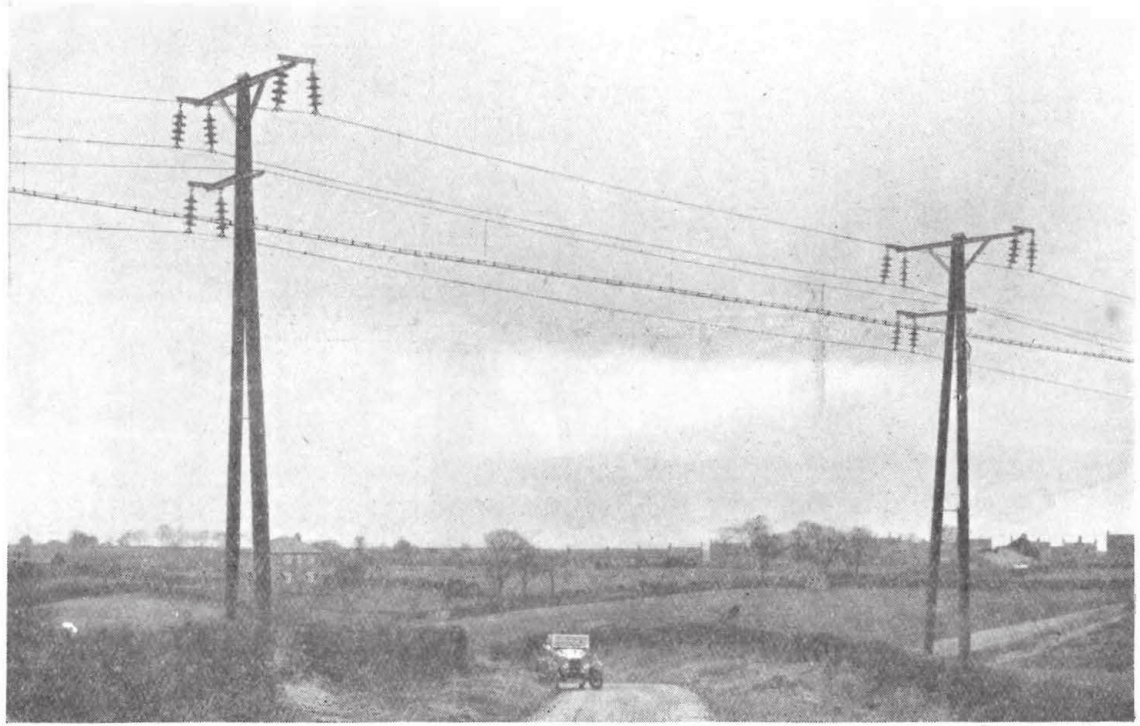
SCOTLAND.—Thomas Land & Son, 73, Robertson Street, Glasgow.
AUSTRALIA.—J. Paton & Co., Macquarie Place, Sydney, N.S.W.
J. Bartram & Son, Pty Ltd., 586, Bourke St., Melbourne.
NEW ZEALAND.—B. L. Donne, Australasia Bank Chambers Custom House Quay, Wellington.
N.E. ENGLAND.—North British Eng. Equipment Co., Milburn House, Newcastle-on-Tyne.
LEEDS.—North British Engineering Equipment Co., Excelsior Buildings, Lands Lane.
CARDIFF.—E. Tompson & Son, Western Mail Chambers.
CALCUTTA.—8, Central Avenue.

THE BRITISH
L. M. ERICSSON MFC. CO., LTD.
International Buildings,
67/73, Kingsway, London, W.C.2

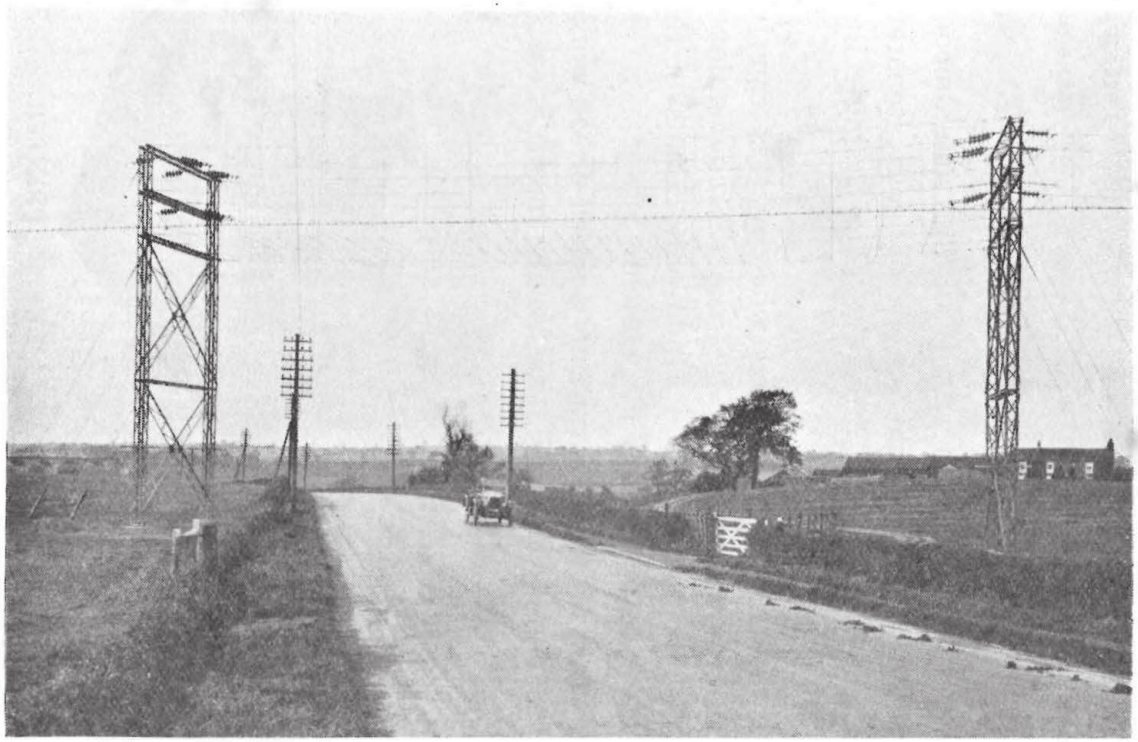
Ericsson Telephones

SIEMENS

OVERHEAD TRANSMISSION LINES



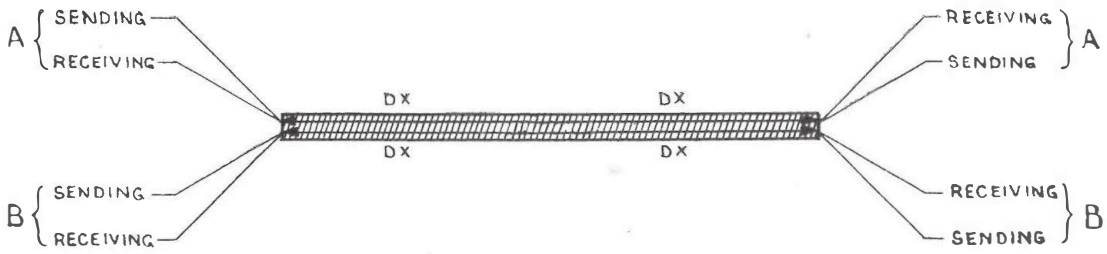
66,000-volt, 3-phase, Overhead Transmission Line, with auxiliary pilot cable suspended from earth wire, crossing a road.



66,000-volt, 3-phase, Overhead Transmission Line, with galvanised steel towers, crossing a main road and P.O. telephone wires.

SIEMENS BROTHERS & CO., LIMITED, WOOLWICH, LONDON, S.E. 18.

The Creed

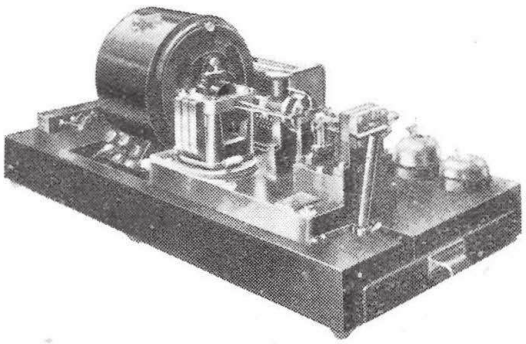


QUADRUPLEX PRINCIPLE

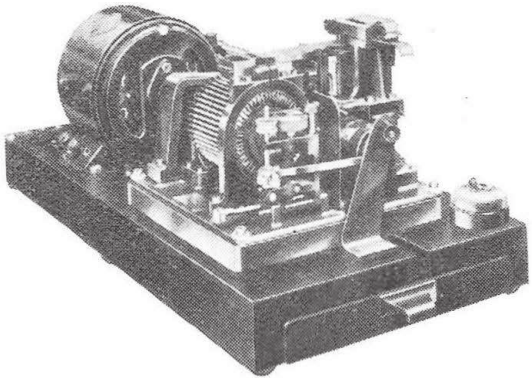
The Creed Quadruplex System admits of the simultaneous automatic transmission at a high speed of four separate independent messages (two in each direction) over a single line connecting two stations.

It is the only system yet designed whereby this can be accomplished, and it differs considerably from the conventional Quadruplex arrangement hitherto used which only admits of the automatic working of one section of the system.

Using the well-known Creed instruments a speed of 120 words per minute on each channel each way (that is, 480 in all) is easily maintained.



CREED RECEIVER.



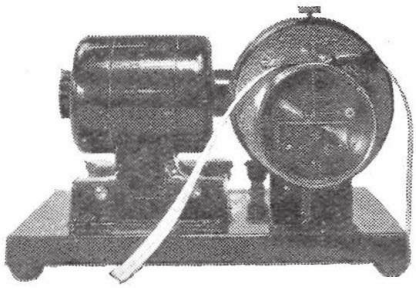
CREED PRINTER.

Write for particulars to

CREED & CO., LTD.,

Telephone : Croydon 2121.

Quadruplex System.



CREED TRANSMITTER.

During one of the heaviest snowstorms of this Winter the Creed Quadruplex on a line between London and Manchester maintained a speed of 220 words per minute, that is, 110 on each channel from London to Manchester, throughout the period. This achievement will more readily be appreciated when it is realised that the line—which was handling newspaper traffic—was the only one to maintain this speed, all other lines between the same points either having to work Simplex or being down altogether.

The difficulty previously experienced in Quadruplex working known as the "B" kick has been successfully overcome in the Creed Quadruplex System, and maintenance of the system is accomplished without difficulty.

TELEGRAPH WORKS,

CROYDON, SURREY.

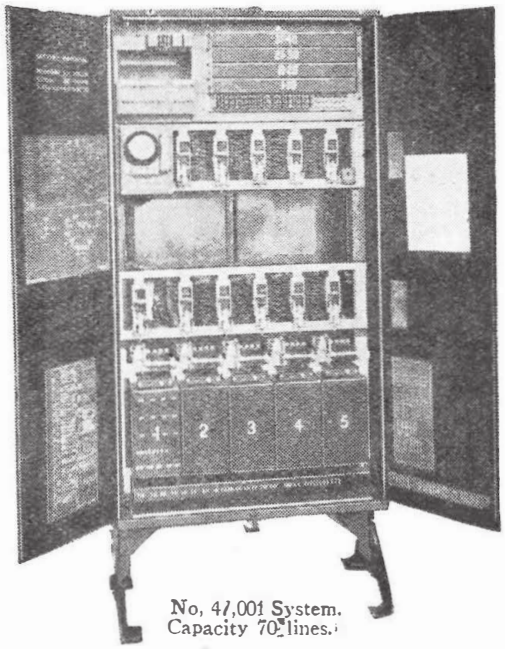
Telegrams: "Credo, Croydon."

Standard

FORMERLY

Western Electric

Automatic Telephone Systems



No. 47,001 System.
Capacity 70 lines.

STANDARD Automatic Private Branch Exchanges are essential to all business houses. They represent a time-saving factor of great value and increase the general efficiency of any organisation.

Here are some points for consideration :—

1. No operator is required, therefore the annual cost is negligible compared with a manually-operated switchboard.
2. The apparatus is ready for use day and night—or 8,760 hours per annum.
3. Absolute secrecy is secured on every call without any special manipulation of the Set on the part of the user.
4. High speed of operation. There is no waiting on the No. 47001 system, as the number is selected by the mechanism during the process of dialling.
5. The caller is instantly advised if the wanted line is engaged and (should he decide to hold the telephone for a minute or so) he is automatically connected as soon as the required line is free.
6. The caller is given confidence in the apparatus as he supervises the call and can hear the distant bell ringing.
7. The apparatus is simple to instal, being in standardised unit form.
8. It is economical to house because it may be fitted in a position which would be unsuitable for an operator.

Standard Telephones and Cables Limited

Connaught House, Aldwych, London, W.C.2.

'Phones: CENTRAL 7345 (10 lines). Works: HENDON, NORTH WOOLWICH and NEW SOUTHGATE. Branches: Glasgow, Leeds, Birmingham, Manchester, Cardiff, Liverpool, and Dublin.

THE
Post Office Electrical Engineers' Journal

UNDERGROUND TELEGRAPH CIRCUITS WORKED FROM UNIVERSAL BATTERIES.

In the *I.P.O.E.E. Journal* for April, 1921, Messrs. R. T. King and E. J. Barnes described a Relay and Galvanometer, each with four windings, used in connection with Automatic signalling experiments. The apparatus gave Cable circuits supplied from Universal batteries the same freedom from the effects of outside interference as circuits provided with Independent batteries.

In 1923 the Telegraph Section, Engineer-in-Chief's Office, conducted experiments to compare the speeds obtainable on a loop circuit, equipped, in one case with Standard "B" Relays and Independent batteries, and in the other with Relays having four windings and Universal batteries. Practically the same duplex speeds were obtained in both circuits.

A limited supply of these new Relays and Galvanometers was then obtained. The items are described as "Relay Standard H," and "Galvanometer, double, differential." Details of the winding and resistances of the Relay are shown in Fig. 1.

In addition to its special function, for which the duplicate windings are required, it can be used as an ordinary 'B" Relay by utilising one set only of the main coils, or as a "G" Relay by bringing in the Vibration Coils.

The Galvanometer has four separate coils of 44 ohms, each shunted by 300 ohms.

For duplex working the apparatus is connected as shown in the theoretical diagram, Fig. **2.**

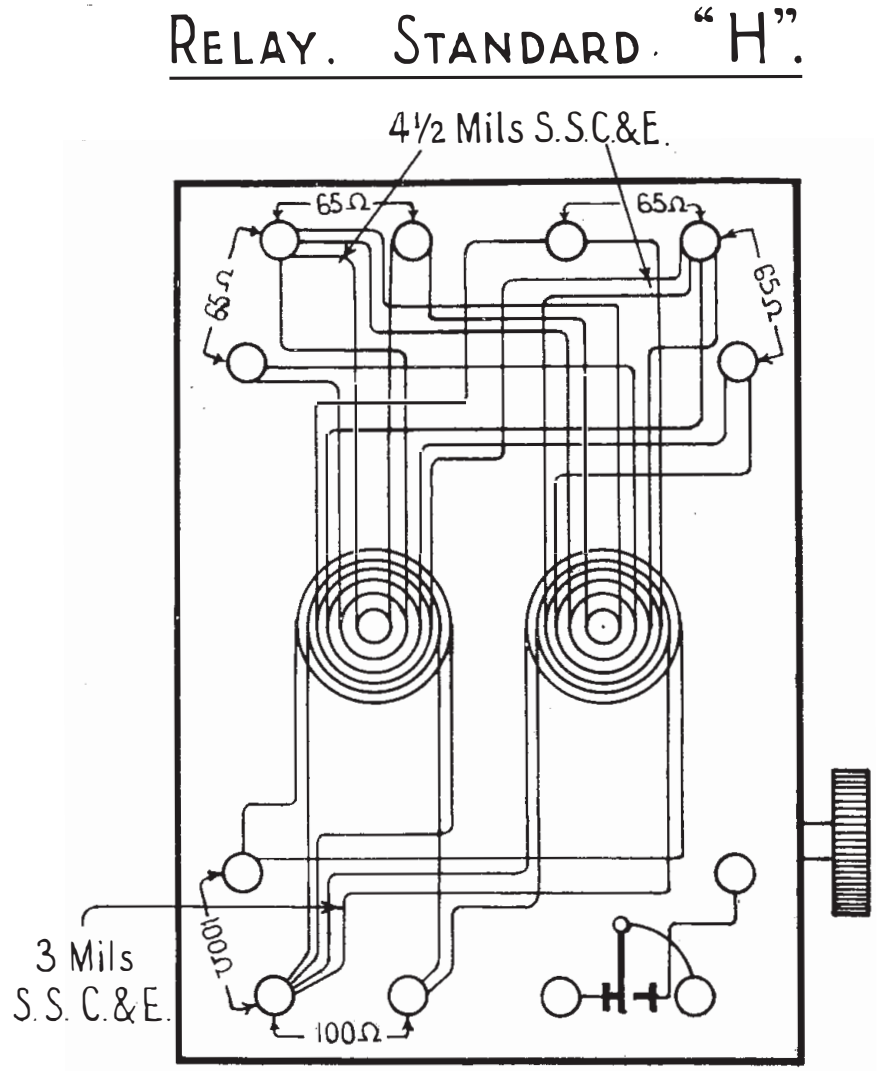

RELAY. STANDARD "H".
4½ Mils S.S.C.&E.
65Ω
65Ω
65Ω
65Ω
3 Mils
S.S.C.&E.
100Ω
100Ω
The Resistances shewn are those between the neighbouring Terminals. The effect of a copper or positive current Flowing in a counter-clockwise direction in one or more of the coil circuits is to move the tongue to the right. i.e., marking.

FIG. 1.

If the ' B " line link at the Test Box be disconnected, a single line can be used with a set wired for the " H " Relay. Twice the

normal resistance of the line will, however, be required in the Rheostat when balancing for duplex.

The circuit of the " B " line is arranged to be in every respect similar to the circuit of the " A " line, but the currents induced in the two circuits pass through the apparatus in such a way as to produce opposite magnetic effects. Currents arising from outside influences, *e.g.*, neighbouring cable circuits, or earth currents, therefore neutralise each other.

The " A " line only is used for the signalling current. The compensation circuit reproduces the line side conditions closer than the standard method because a Relay coil and a Lamp resistance are in circuit after the Rheostat.

The current in the compensation circuit traverses two coils of the Relay and Galvanometer, hence it is necessary to adjust the Rheostat to twice the value of the line resistance. The magnetic effects of line and compensation currents in the sending apparatus are then equal and opposite. A pamphlet, E.-in-C. No. 167, has been issued explanatory of the system.

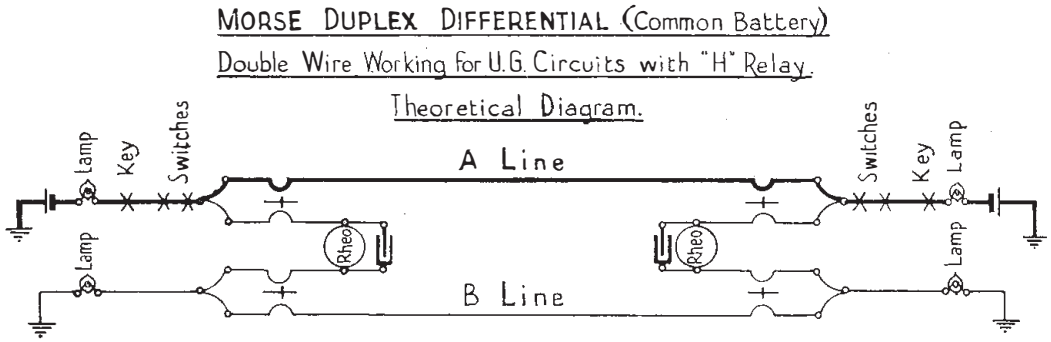

MORSE DUPLEX DIFFERENTIAL (Common Battery)
Double Wire Working for U.G. Circuits with "H" Relay.
Theoretical Diagram.
Lamp
Key
Switches
A Line
Switches
Key
Lamp
Lamp
Rheo
Rheo
Lamp
B Line
Duplex Conditions. Currents due to induction pass from the A and B Lines in an opposite direction through duplicate windings of the relay and galvanometer at each office The magnetic effects are therefore balanced and the Duplex Conditions undisturbed.

FIG. 2.

The first circuit employing the new apparatus was installed in April, 1924, between London and Huddersfield, this circuit having previously proved unworkable with the " B " Relay and Universal batteries. Two other circuits, LE—MR, LE—LV, which were subject to serious inductive disturbance and gave much trouble when routed on adjacent pairs, are now working quite satisfactorily with " H " Relays.

A multiplex circuit has been equipped with the apparatus recently and further extensions are contemplated.

The circuits at present working are as shown :—

Circuit.	Mileage.	Conductor.	System.
TS HF	211.8 miles	40 lb. 203.7 M. 100 ,, 8.1 ,,	Morse dx.
TS YO[1]	219.9 ,,	40 lb.	,, ,, } Adjacent Cable pairs.
TS YO[2]	,, ,,	,,	,, ,, }
LE MR	83.9 ,,	,,	,, ,, } Adjacent Cable pairs.
LE LV	120.7 ,,	40 lb. 83.9 M. 100 ,, 36.8 ,,	,, ,, }
TS LV	221.3 ,,	150 lb. 122.5 M. 100 ,, 94.4 ,, 40 ,, 4.4 ,,	Baudot quadruple duplex.

The system has the following advantages :—

(*a*) The space required for loop batteries is saved and the heavy charges incurred for their maintenance avoided.

(*b*) Less power is required, the line resistance is half that of a circuit employing an independent battery.

(*c*) Faults arising from low insulation of batteries are eliminated.

(*d*) Special arrangements to deal with earth currents are unnecessary.

There are, however, three disadvantages.

(*a*) The Cable pairs cannot be used for superposing.

(*b*) Unless provided with similar apparatus, circuits in the same Cable (other than metallic loop circuits) will suffer inductive disturbance.

(*c*) The " B " line is subject to inductive disturbance from its associated " A " line. This, up to the present, has created no difficulty.

R.P.S.

WAR OFFICE PNEUMATIC TUBE CENTRE.

J. E. McGREGOR, A.C.G.I., A.M.I.E.E.

General. This pneumatic tube installation, which represents the latest developments in pneumatic tube practice, consists of an Exchange Centre to which surrounding offices are connected by short pneumatic street tubes, and where the messages to and from these

offices are transferred from and to trunk tubes connecting the Tube Room at the War Office with the C.T.O., thus saving the large expenditure that would be incurred if all the offices were connected through to the C.T.O. by individual tubes. A list of the offices connected is given in the Appendix.

The street tubes are connected to electrically operated rotary switches which transfer the carriers automatically between the street tubes and house tubes terminated in Flap Terminals through which the carriers are delivered or inserted.

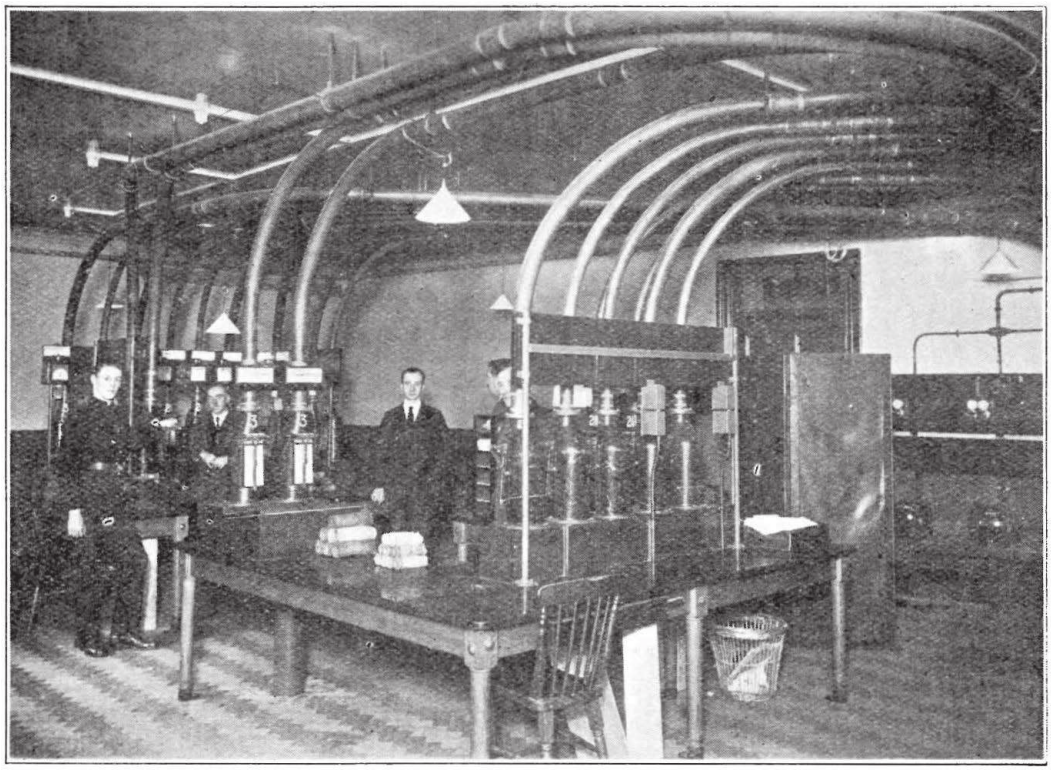


FIG. 1.—TUBE ROOM.

In the case of the trunk tubes to and from the C.T.O. no switch is required at the delivery end and the carriers are discharged automatically through the flap terminals directly into the Instrument Room at the C.T.O. and the Tube Room at the War Office respectively.

The whole of the switching and signalling arrangements are of a novel character and represent a great deal of experimental work, the result being that the tube terminals in the Exchange are located in a very compact form, all the switching arrangements for the insertion and reception of carriers into and from the street tubes being carried out automatically in a separate room, and the amount of manual work being reduced to a minimum. In addition to the

large reduction in staff, owing to the abolition of the heavy hand-operated pneumatic switches which would otherwise have been required, the automatic discharge of the carriers also means an avoidance of delay in handling the messages.

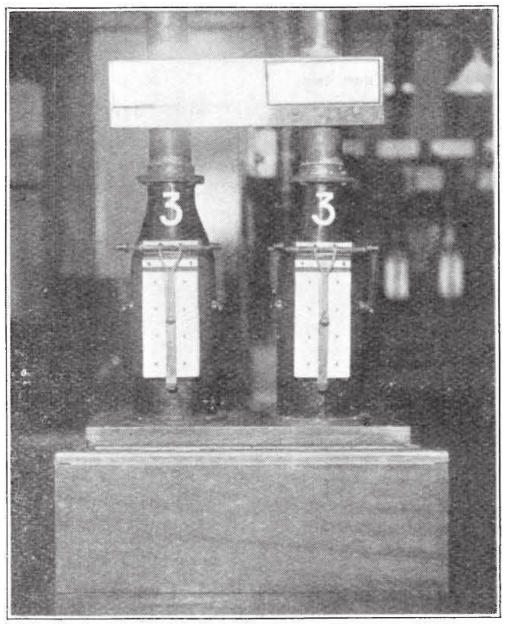


FIG. 2.—FLAP TERMINALS.

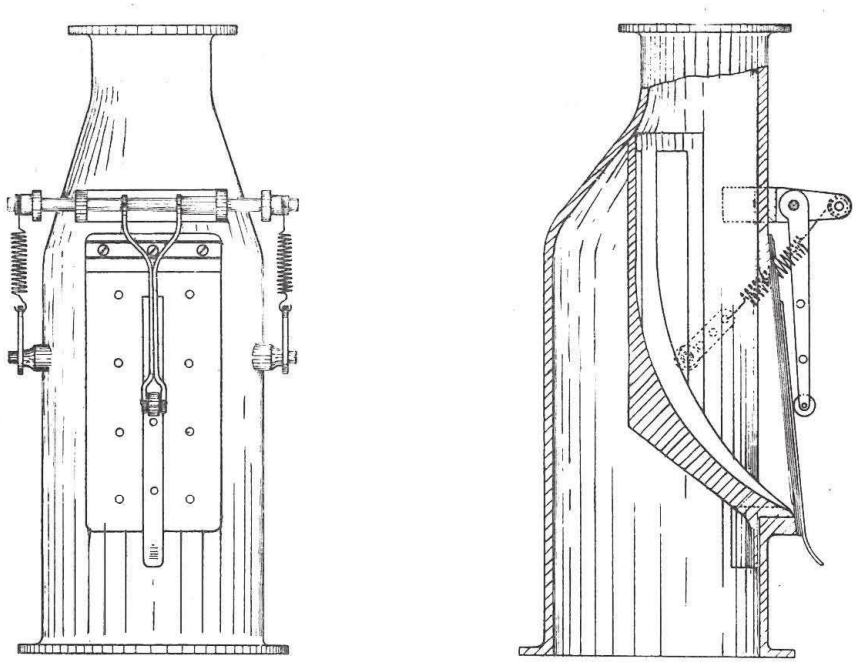


FIG. 3.—FLAP TERMINAL.

In the outlying offices connected up, the messages can be inserted direct into the street tube by the receiving officer at the counter with no more trouble than that associated with the use of

house tubes, a flap terminal again being used, and the delivery of the messages can be made direct to the instrument room (as at the C.T.O.), or to the various sending out rooms, no auxiliary house tube system being required at the various offices.

The special apparatus used has been invented and designed in the Power Section of the Engineer-in-Chief's Office and erected by the London Engineering District.

Compressor Room. The War Office Tube Centre is served by three electrically-driven air compressors of Messrs. Weir's manufacture. These are of the horizontal type and are each capable of delivering 600 cubic feet of air per minute at about

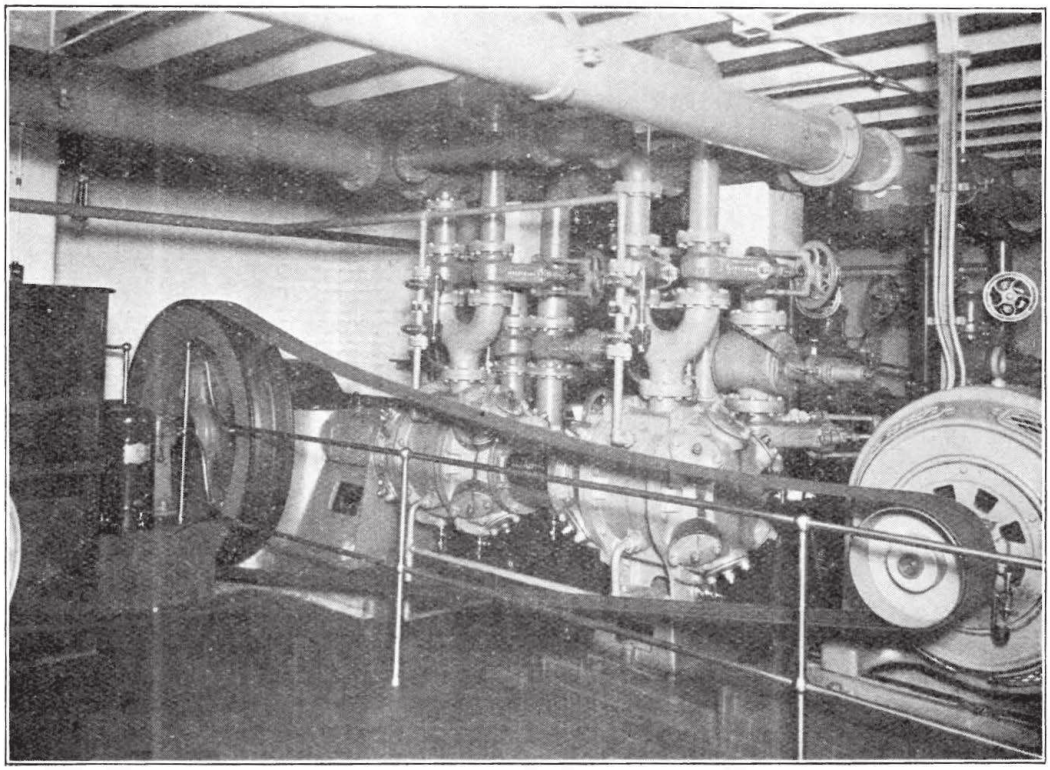


FIG. 4.—AIR COMPRESSOR.

10 lbs. per square inch pressure, or 12 to 16 inches vacuum, incoming tubes being operated by vacuum and outgoing tubes by pressure. The compressors are belt-driven from electric motors of 40 B.H.P. capacity and run at 130 r.p.m., the full motor speed being 600 r.p.m. The two trunk tubes from the C.T.O. are supplied with air under pressure from the C.T.O. Valves are provided so that any of the compressors may be used for either service, vacuum or pressure.

From the Compressor Room the air is taken to pressure and vacuum headers in the *Switch Room* which in turn are connected

through electrically controlled, pneumatically operated valves to the pneumatic tube switches.

These *Air Supply Valves,* a bank of which can be seen in the illustration (Fig. **5**), are operated by auxiliary Westinghouse valves. In these a solenoid causes a piston to open or close ports connected to an auxiliary air supply. This in turn moves a piston in the main valve against a spring opening ports which connect the tubes to the main air supply. On switching off, the valve body is connected to atmosphere and the spring returns the piston to the "off" position.

In the case of tubes working both "up" and "down," a second similar valve determines whether the air supply is vacuum or pressure.

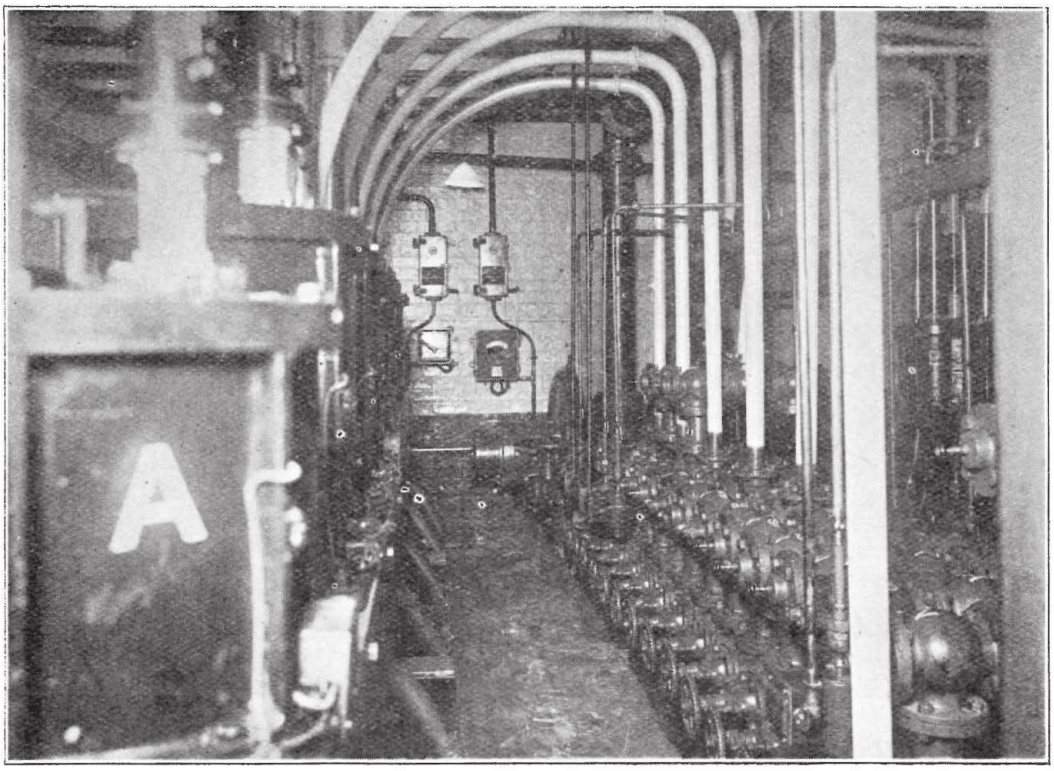


Fig. 5.—Pneumatic Switch Room.

In the Switch Room are located four Keith Blackman Centrifugal Blowers of 700 cu. ft. per min. capacity, two of which are used alternatively for pressure, and two for vacuum, for operating the house tubes connecting the Pneumatic Switches with the Tube Room.

The Pneumatic Switches are operated by means of magnetic clutches connected through chains and gear wheels to line shafting driven by two alternative motors of 3 H.P. capacity, a simple

throw-over clutch being provided by which either motor is connected to the shafting.

The *Pneumatic Switch* consists of a fixed open cylindrical frame with top and bottom plates having orifices to which the street and house tubes are connected and also the air supply pipes (vacuum and/or pressure).

Inside this frame is a rotating body consisting of three tubular sections welded at the top and bottom to plates similar to those on the outside frame. Packing rings are inserted round the orifices to prevent leakage of air. When receiving, the carrier, which has been inserted in the street tube at the "out" office through a flap terminal, passes from the street tube into one of the tubular compartments of the switch, where it is held by a grid covering the

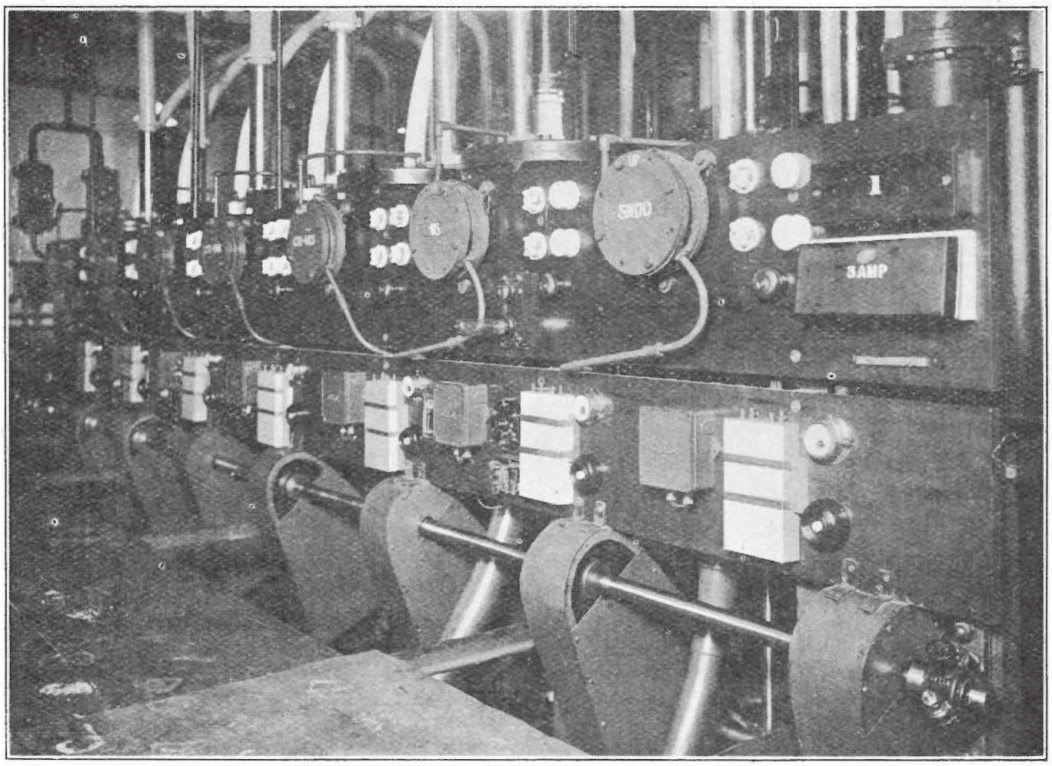


FIG. 6.—PNEUMATIC SWITCH ROOM. CONTROL BOARD.

vacuum supply pipe. As the carrier rests against the grid it interrupts the flow of air, causing a considerable difference of pressure before and behind the carrier.

Small pipes are led from above and below the switch, transmitting these pressures to a *Differential Indicator*.

The *Differential Indicator* consists of a cast iron case divided into two compartments by a rubber diaphragm stiffened by aluminium discs proportioned to the pressures used. The move-

ment of the diaphragm is transmitted by an axial pin to a pair of contacts, thus completing or opening an electrical circuit. The diaphragm is biassed by a spring against the difference of pressure due to the normal flow of air through the switch, and contact is only made when the difference of pressure is increased owing to the presence of the carrier in the switch. As soon as this contact is made, it completes a circuit through auxiliary plunger contacts on the switch and the magnetic clutch is energised and couples the switch to the shafting by a pinion and crown wheel.

When the switch leaves its normal position the differential indicator ceases to function and a retaining contact is provided to

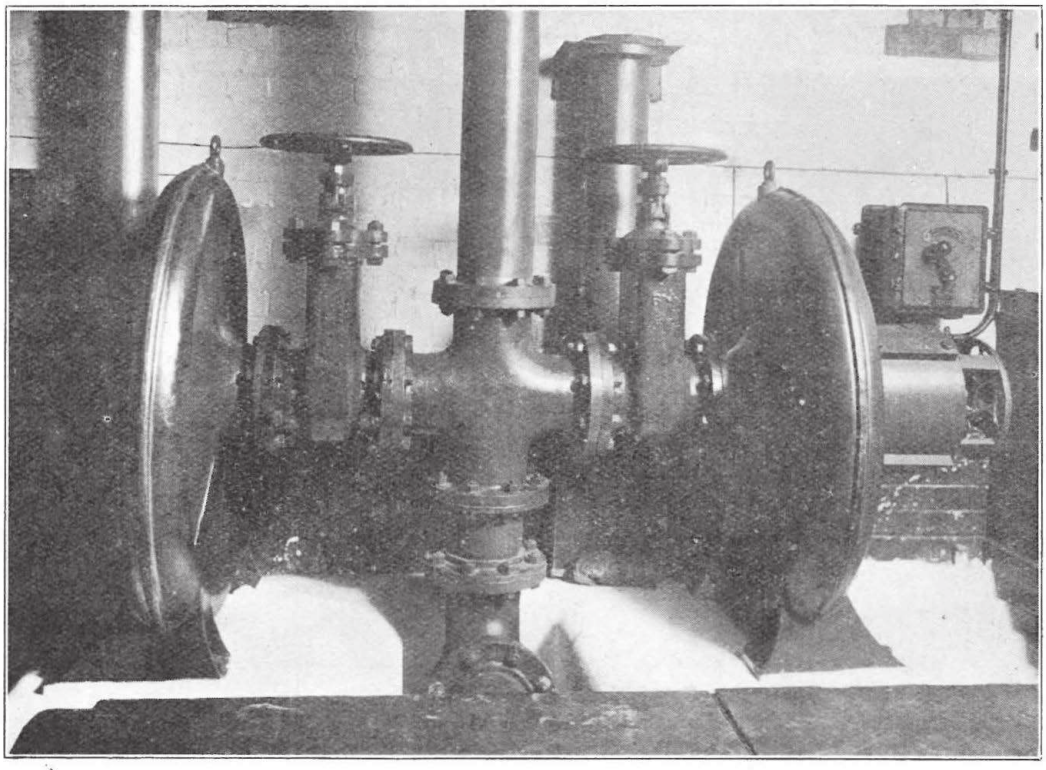


FIG. 7.—CENTRIFUGAL BLOWERS.

maintain the electrical circuit. When the switch has made one-third of a revolution the carrier is brought into position to be blown into the house tube by the low pressure air from the centrifugal blowers, and the retaining contact is opened by means of a ramp fixed on the rim of the rotating part, leaving the switch ready to receive another carrier.

The switches are fitted with friction band brakes to minimise any variation in torque required by the various switches and to ensure stoppage at the correct points. A condenser is inserted to reduce sparking at the contacts.

The carrier passes through the house tube and is blown through the flap terminal in the Tube Room.

For sending from the War Office Centre the process is reversed, the carrier being drawn by vacuum from the flap terminal to the switch, which rotates and delivers the carrier to the street tube, whence it is discharged at the distant office through a flap terminal.

Where there is likelihood of the carriers being discharged at excessive velocity a bye-pass is fitted near the end of the tube releasing the pressure behind the carrier to atmosphere.

Signal and Air Control Circuits. The signal circuits are arranged, not only to give the ordinary block instrument indica-

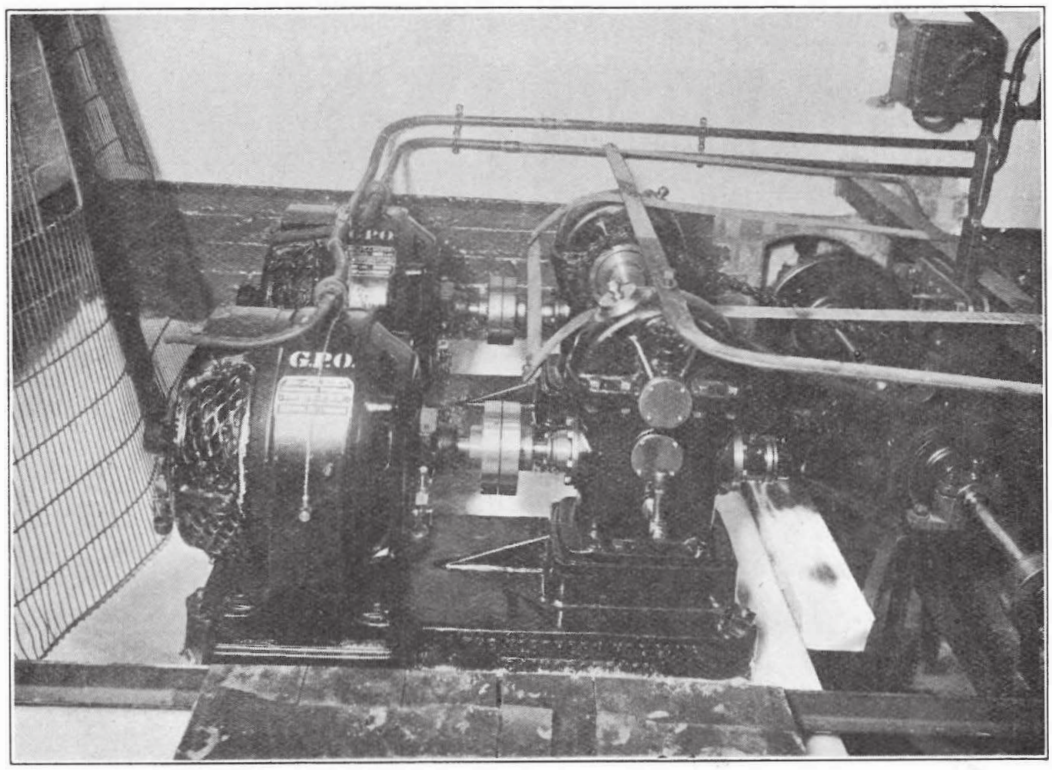


FIG. 8.—DRIVING MOTORS.

tions, but also to operate the air supply valves for the shorter tubes through which a considerable amount of air would otherwise be wasted when not in use, as the far end is open to atmosphere.

In the case of long tubes this waste is greatly reduced owing to the frictional effect of the tube on the air, and it is only at rare intervals that there is no carrier in the tube. In these tubes the time interval between the carriers would be too great if only one carrier were allowed to travel at a time and Signallers are placed to indicate the passage of a carrier at a certain distance from the sending point, after which another carrier may be inserted. Up

till now, dependence has been placed on a timing control for loading long tubes, which is not satisfactory, as it does not prevent carrier after carrier being inserted if a carrier has stopped and so causing the tube to become jammed. With a definite space interval at the start and an open end trouble from this cause will not arise.

On the trunk tubes to the C.T.O. this corresponds to a time interval of 10 to 15 seconds between the despatch of the carriers, which is ample, as there can be no delay in discharging the carrier from the tube, this being unrestricted by the flap terminal, which is not dependent on the attention of a tube attendant.

The Signaller used is a *Differential Indicator Signaller* similar to the differential indicator used for operating the switches, but of

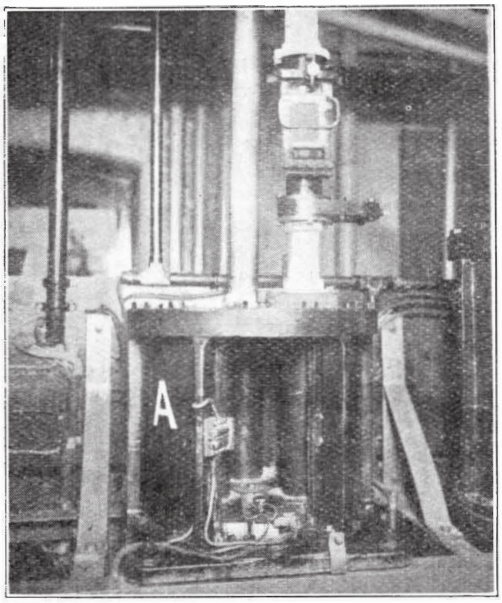


FIG. 9.—PNEUMATIC SWITCH.

a more sensitive type and with a greater range of adjustment with an external setting. The pressure pipes actuating the signaller are connected to the street tube at two points about 24 feet apart and the difference of pressure caused by a carrier traversing this section causes a contact to be made.

The tubes are automatically blocked when sending from the War Office by means of a relay in the retaining contact circuit of the Pneumatic Switches.

On shorter tubes, when arranged for receiving, the line is blocked by means of a press button at the distant station, and the same signal operates a Teleswitch which causes the air supply valve to open. The Teleswitch is a form of relay with contacts suitable for 200 volts, which are closed with the first current

impulse, opened with the next, closed with the third and so on. When the carrier arrives in the Pneumatic Switch a relay is operated which clears the block signal and operates the Teleswitch again, cutting off the air.

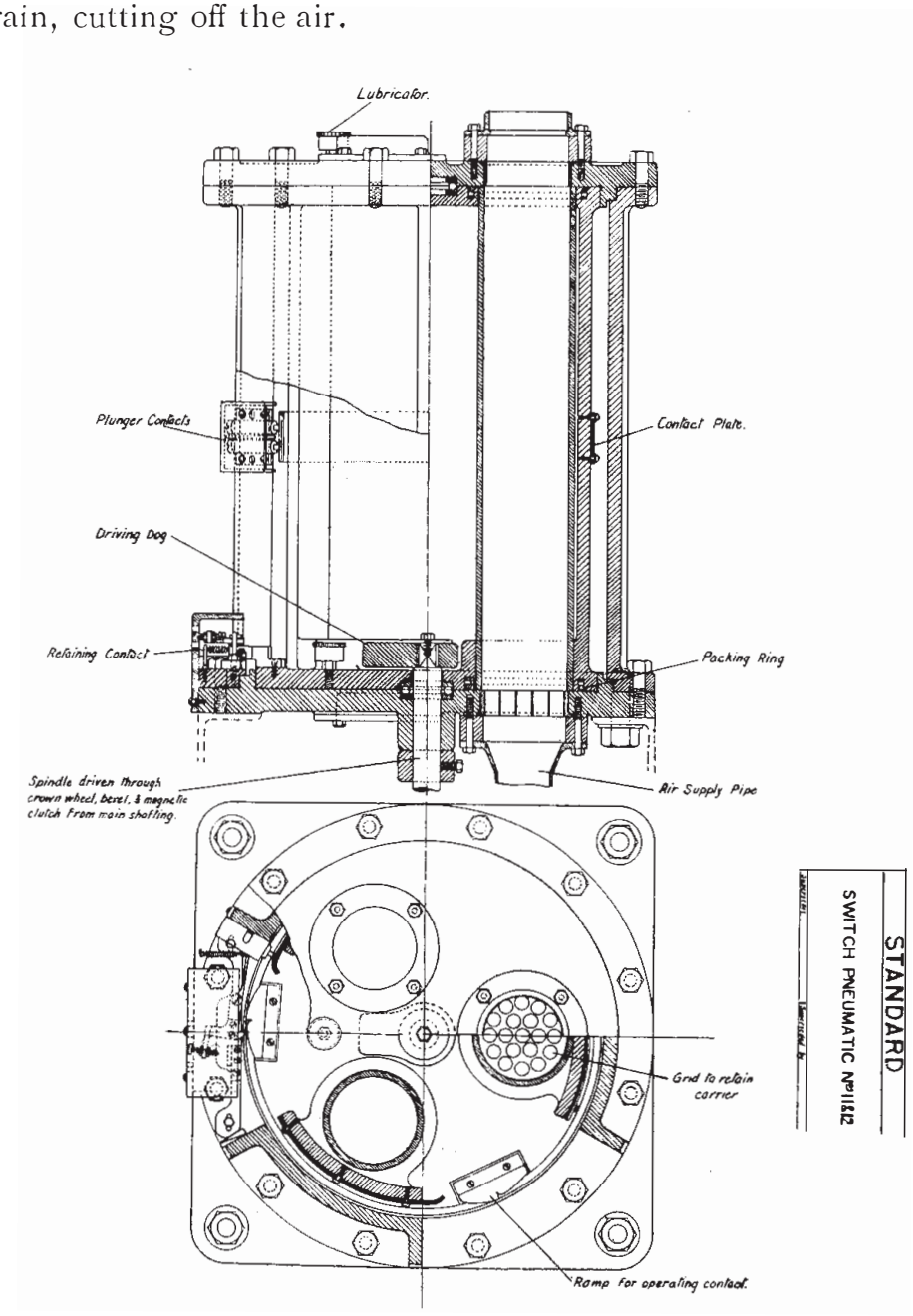


FIG. 10.—PNEUMATIC SWITCH.

For sending on these tubes a similar arrangement was installed, but was not found to be quite satisfactory as no indication was given to the tube attendant that the air supply had actually been switched on. (In the case of a carrier being sent from an out office to the War Office it would not leave the attendant's hand

until the vacuum was on the tube.) On these tubes therefore a modified form of starting switch has been installed; the handle is first pressed in, sending the block signal, and then the arm is brought over to the " on " position, when the air valve is switched on and the arm held over by a retaining electro magnet.

When the carrier arrives at the distant office the attendant depresses his push button, clearing the block signal and releasing the switch arm, which is returned to the off position by a spring, cutting off the air supply.

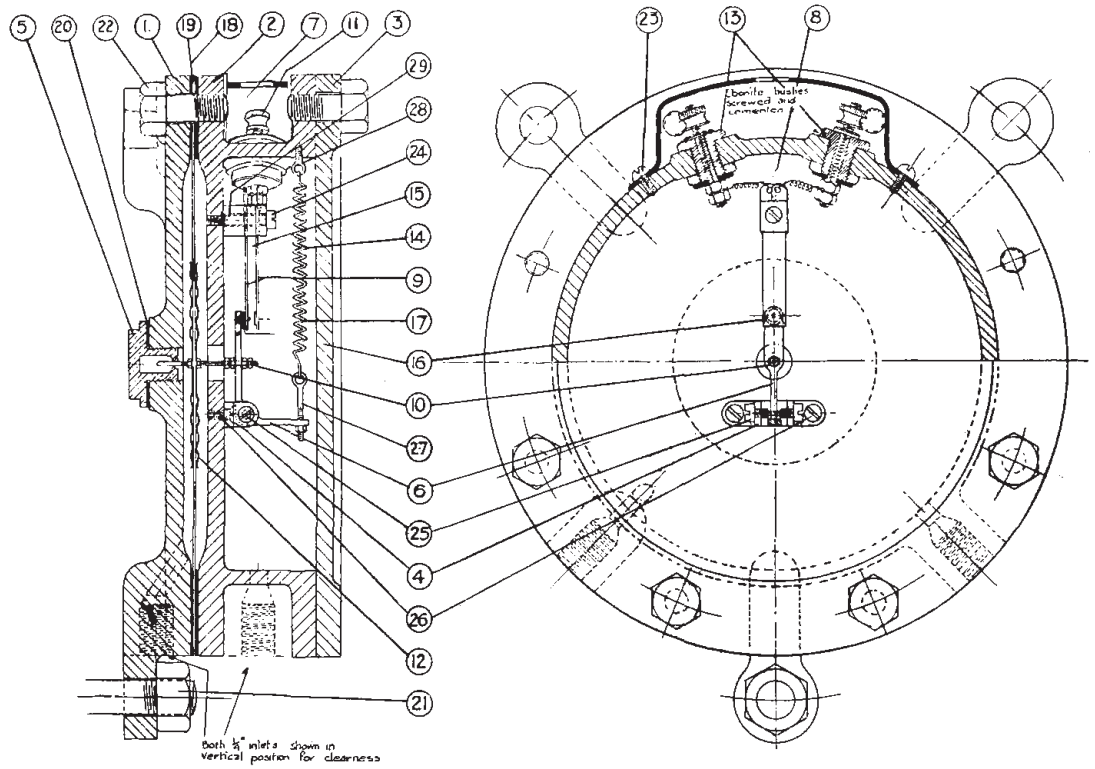


FIG. 11.—DIFFERENTIAL INDICATOR.

On tubes arranged for two-way working the signalling is automatic, but the control of the air supply is by hand. Automatic control of this by a further modification of the switch used when sending on short tubes, combined with the use of a Teleswitch for receiving, has been devised, but the wiring becomes very complicated and it is found that the arrangement used works well in practice.

The current for the signal circuits is supplied from rotary DC/DC converters (double-wound generators) at the War Office, power leads being run to the outlying offices, replacing the batteries shown in the illustration. The air supply valves and

magnetic clutches are connected to the public electricity supply mains.

Costs. The cost of the whole scheme, including laying certain tubes for newspapers from the C.T.O. (which are not served by

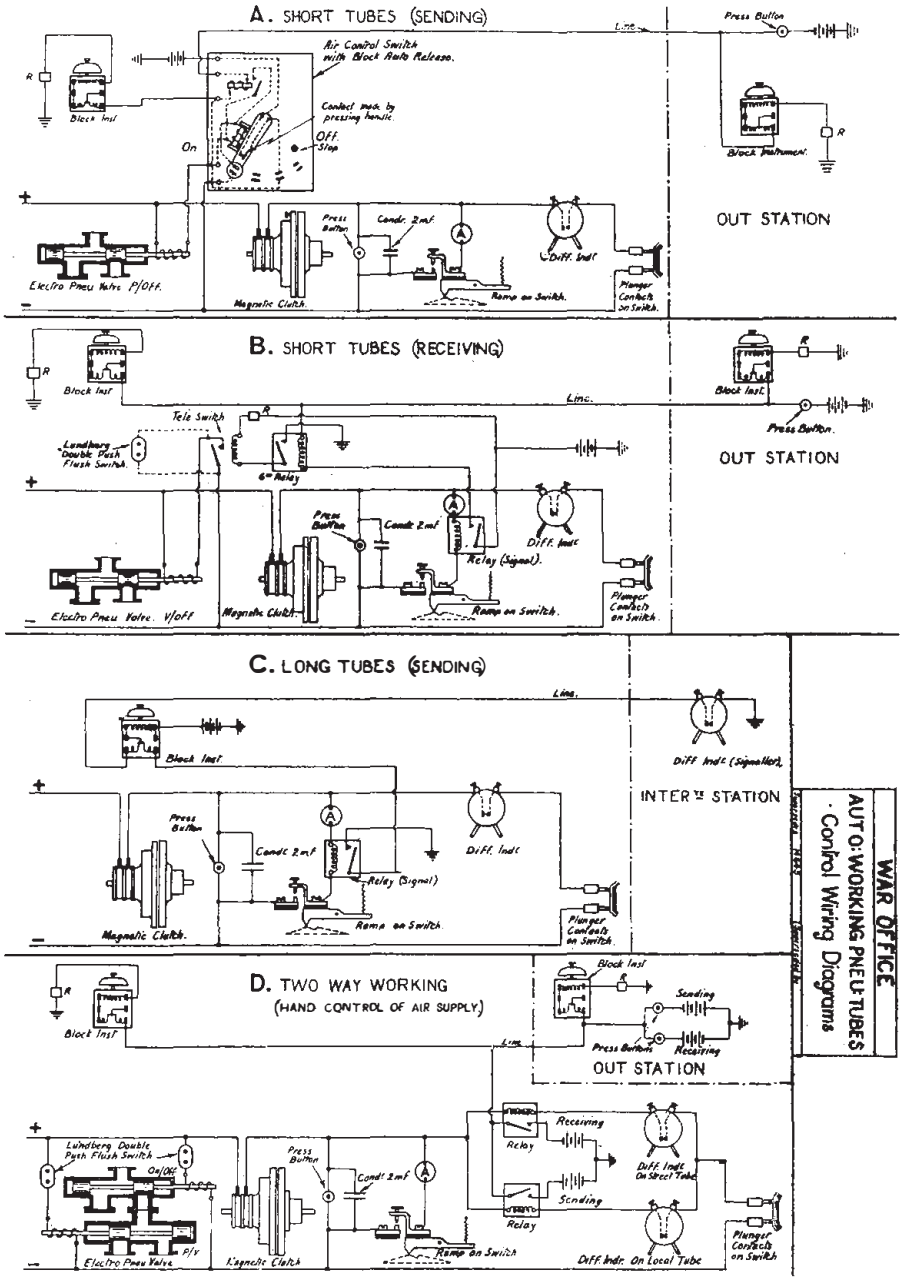


FIG. 12.—CONTROL DIAGRAM.

the War Office Centre but which were laid at the same time), the automatic switching apparatus, and all incidental charges, was in the neighbourhood of £60,000, and it may perhaps be of interest to know how such a large expenditure can be justified.

In the first place, the introduction of tubes admits of the abolition of transmission of telegrams by wire and the saving on this account alone, amounting to some thousands of pounds per annum, having regard to the number of offices served by the tubes, was calculated to justify the expenditure, while the introduction of automatic working results in a further considerable saving.

There are, however, other considerations. Although an individual telegram cannot perhaps be sent more quickly by tube than by wire, a number of messages can be conveyed in one carrier and the acceleration in transmission becomes very marked when large numbers of telegrams are handed in at one time, or where lengthy telegrams, or telegrams containing code or cypher, are required to be forwarded.

The provision of tubes for newspapers in the same trench as the trunk tubes afforded a means of supplying the facilities at a lower charge than would have been the case if it had been necessary to open the ground for the purpose, and at the same time the revenue from these tubes allows for a certain margin of profit and can therefore be regarded partly as a set-off against the interest charges on the initial outlay.

APPENDIX.

LIST OF OFFICES CONNECTED TO THE WAR OFFICE CENTRE.

Office.	Direction of working.	Diameter of Tube.	Remarks.
C.T.O.	*Via* Embankment	3″	The routes are used alternatively, one tube each way being sufficient to carry the traffic owing to the use of the intermediate signaller.
	Up	3″	
	Down		
	Via W. Strand	3″	
	Up	3″	
	Down		
Parliament St. B.O.	Up & Down	2¼″	
Foreign Office	Up & Down	2¼″	
Victoria Street and S.W.D.O.	Up	2¼″	
	Down	2¼″	
Admiralty	Up	3″	
	Down	3″	
Houses of Parliament	Up	3″	This tube is to be connected through to the C.T.O. at night time.
*W. Strand B.O.	Up	3″	
	Down	3″	
St. James St. B.O.	Up	2¼″	
Charles Street	Up	2¼″	
*Charing Cross Station	Up & Down	2¼″	

* Not connected at time of writing.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE, IN EACH ENGINEERING DISTRICT AS AT 31ST DEC., 1925.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
474,323	619	4,181	54,885	461	London	22,944	54,482	1,619,737	48,178
57,406	1,900	20,164	57,421	1,601	S. East	3,803	21,615	100,178	13,400
60,906	4,496	26,248	46,013	1,848	S. West	13,749	5,746	94,010	29,199
47,762	8,480	31,238	42,088	5,124	Eastern	12,860	26,687	56,477	45,699
80,108	8,521	41,715	52,442	3,118	N. Mid.	19,687	37,387	140,487	79,328
58,269	4,894	26,415	57,694	4,181	S. Mid.	12,099	16,168	112,592	84,950
51,876	5,087	28,697	45,527	1,895	S. Wales	5,229	19,262	85,457	67,082
84,728	8,118	24,291	43,619	5,244	N. Wales	12,087	34,272	161,885	48,264
130,937	1,652	17,142	45,812	2,954	S. Lancs.	12,696	68,280	347,712	31,931
78,365	6,322	30,118	41,922	2,641	N. East	8,205	31,223	175,319	24,933
52,700	3,645	23,969	36,429	2,485	N. West	8,358	30,412	103,646	32,892
40,064	2,465	15,535	24,049	2,140	North	3,383	8,738	71,651	47,585
18,392	4,833	6,074	11,837	197	Ireland N.	140	213	29,167	2
54,545	5,495	21,974	33,167	1,177	Scot. East	1,943	7,951	98,728	38,200
75,262	7,466	23,357	40,054	819	Scot. West	12,107	21,998	188,999	23,383
1,365,643	73,993	341,118	632,959	35,885	Totals.	149,290	384,434	3,386,045	615,026
1,334,917	74,332	337,558	624,507	36,055	Figures on 30th Sept., 1925.	150,189	359,235	3,292,280	572,197

AUTOMATIC EXCHANGE DEVELOPMENT.

PRESS BUTTON TYPE DIALLING EQUIPMENT FOR A POSITIONS.

By J. Hedley, M.I.E.E.

In connection with the introduction of automatic exchange working in large multi-office networks, it generally happens that subscribers on certain nearby manual exchanges have a large community of interest with the subscribers on the automatic exchange.

Calls from the Museum manual exchange subscribers to the Holborn automatic exchange subscribers will be a particular case when the director system commences to operate in London. The present standard method of handling this class of traffic for the London system will be by means of order wire working from the manual exchange to a Cordless B. operator in the automatic exchange.

An experimental trial equipment will be installed in the Museum manual exchange, whereby the A operators at that exchange will be in a position to complete calls for subscribers on the Holborn automatic exchange without the aid of a B operator at the latter point and without increasing the value of the call to the Museum A operator.

The scheme proposed is as follows:—

1. Existing A position cord circuits and operators' telephone circuit unaltered.
2. Each position will be equipped with a sender lamp and strip of 10 keys of the press button type, similar to those being provided on Cordless B. positions; the key strip and lamp will be associated automatically with

common exchange sending equipment during the setting up of a call only.

3. Each position will be equipped with 4 or 5 jacks outgoing to the automatic exchange. These jacks will be individual to each position, and replace the regular outgoing junction multiple jacks, their location on each position to be such that the operators' reach is the shortest possible. The jacks will be associated with a common group of exchange sending equipment during the setting up of a call and also with a common group of junctions outgoing to the distant automatic exchange after the sending equipment has established connection.
4. The sender circuit as developed for Cordless B position working remains unaltered.

The circuit conditions are shown in the figure. It will be seen that each jack referred to in (3) is associated with a homing rotary line switch, the banks of which have access to a graded group of junctions to the automatic exchange and also to a second homing rotary line switch having access to a graded group of senders for accepting storing and transmitting the number set up by the A operator.

This scheme enables each position to have access to a common group of junctions and also a common group of senders.

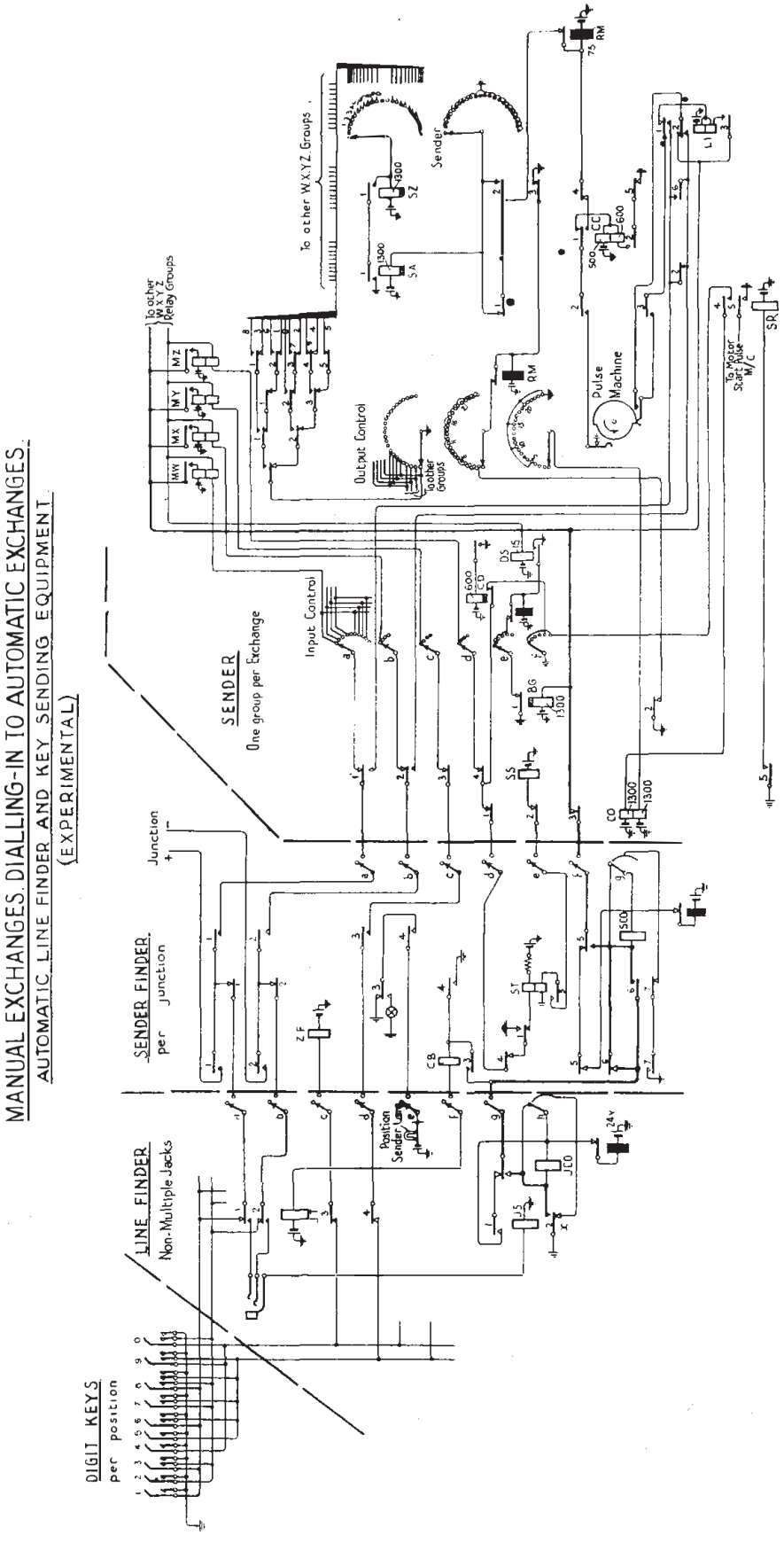
The operating of a call will be as follows :—

1. A operator inserts answering plug, throws speaking key, and obtains calls from subscriber for, say, Holborn 2534.
2. A operator inserts calling plug into jack (individual to her position) labelled Holborn.
3. A operator repeats Holborn 2534 to calling subscriber and upon receipt of steady glow on position sender lamp, will set up on position key strip 2534;
4. Position sender lamp will flash during period of sending out impulses to Holborn Exchange, after which sender lamp will darken and standard supervisory signals will now be received on A operator's cord circuit.

With individual jacks to Holborn on each position, the A operator will be able without testing for an idle jack to insert the calling plug into a vacant jack labelled Holborn, as soon as she hears the exchange name Holborn passed by the calling subscriber, *i.e.*, operation (2) will be an overlapping operation between (1) and (3).

The circuit operations are as follows :—

1. Operator inserts calling plug into jack, Relay JS energises and joins earth to home contact of wiper


MANUAL EXCHANGES. DIALLING-IN TO AUTOMATIC EXCHANGES.
AUTOMATIC LINE FINDER AND KEY SENDING EQUIPMENT
(EXPERIMENTAL)
DIGIT KEYS
per position
1 2 3 4 5 6 7 8 9 0
LINE FINDER
Non-Multiple Jacks
SENDER FINDER
per junction
Junction
SENDER
One group per Exchange
Input Control
Output Control
To other Groups
To other W.X.Y.Z. Relay Groups
To other W.X.Y.Z. Groups
Sender
Pulse Machine
To Motor Start Pulse M/C
Position Sender Can
24 V
MW
MX
MY
MZ
SA
SZ
RM
CC
CD
DS
BG
SS
CO
ST
ZF
CB
SR
L1
J5
J10

"*h*," to operate jack rotary line switch, which rotates to find idle junction.

2. When idle junction found, JCO operates and places earth on wiper "*g*," which is extended *via* normal contacts 6 of relay CB to home contact of wiper "*g*" to operate sender rotary line switch, which rotates to find idle sender.
3. When idle sender found SCO operates and is held *via* normal contact 6 of CB, wiper "*g*," operated contacts of JCO and JS; operated contact 5 of SCO extends earth *via* wiper "*f*" to engage sender, operation of SCO also extends digit key circuit, through to sender.
4. Position sender lamp glows *via* wiper "*e*" operated contact 4 of SCO and normal contact 3 of ST.
5. Operator sets up number on digit keys, after which relay ST operates, *via* its own contact 1, contact 4 of CB, wiper "*d*" contact 1 of CO, operated contacts of CD and earth on sender input control switch. ST locks in series with SS of sender. Position sender lamp now flashes from contact 3 of ST.
6. Relays JT and CB operate in series *via* contact 4 of ST and lock *via* contact 3 of CB wiper "*g*," contacts JCO and JS, *i.e.*, relays JT and CB are maintained in an operated condition until plug withdrawn by operator. Relay JT disconnects digit keys from the circuit. Relay CB extends the junction to the sender and leaves the operation of SCO dependent upon ST.
7. When digits sent out from sender, CO operates, disconnecting SS, which releases ST, thereby disconnecting position sender lamp and de-energising SCO, thus causing sending rotary line switch to return home and joining junction line through to jack for standard supervisory conditions to be obtained on A operator's Cord Circuit.

The advantages of direct dialling by an A operator are:—

1. B operator eliminated, reducing possibility of error due to wrong numbers, after call received from subscriber.
2. Fatigue of A operator reduced, due to short reach with calling plugs.
3. Operating simplified, as after number set up, call proceeds automatically.
4. Better service, as 4 figure number can be set up within two seconds after repeating to calling subscriber.
5. Better service, as errors confined to one operator only.
6. Fewer A operators required, as call value reduced.

LEEDS TELEPHONE AREA.

OPENING OF NEW AUTOMATIC EXCHANGES.

H. W. DIPPLE, A.M.I.E.E.

THE opening of the new automatic exchanges at Chapeltown, Headingley, Roundhay, and Stanningley, on 7th November, 1925, represents a further stage in the conversion of the Leeds area to Automatic working. The scheme was planned by the Post Office in 1913, but owing to war-time difficulties it was not until 18th

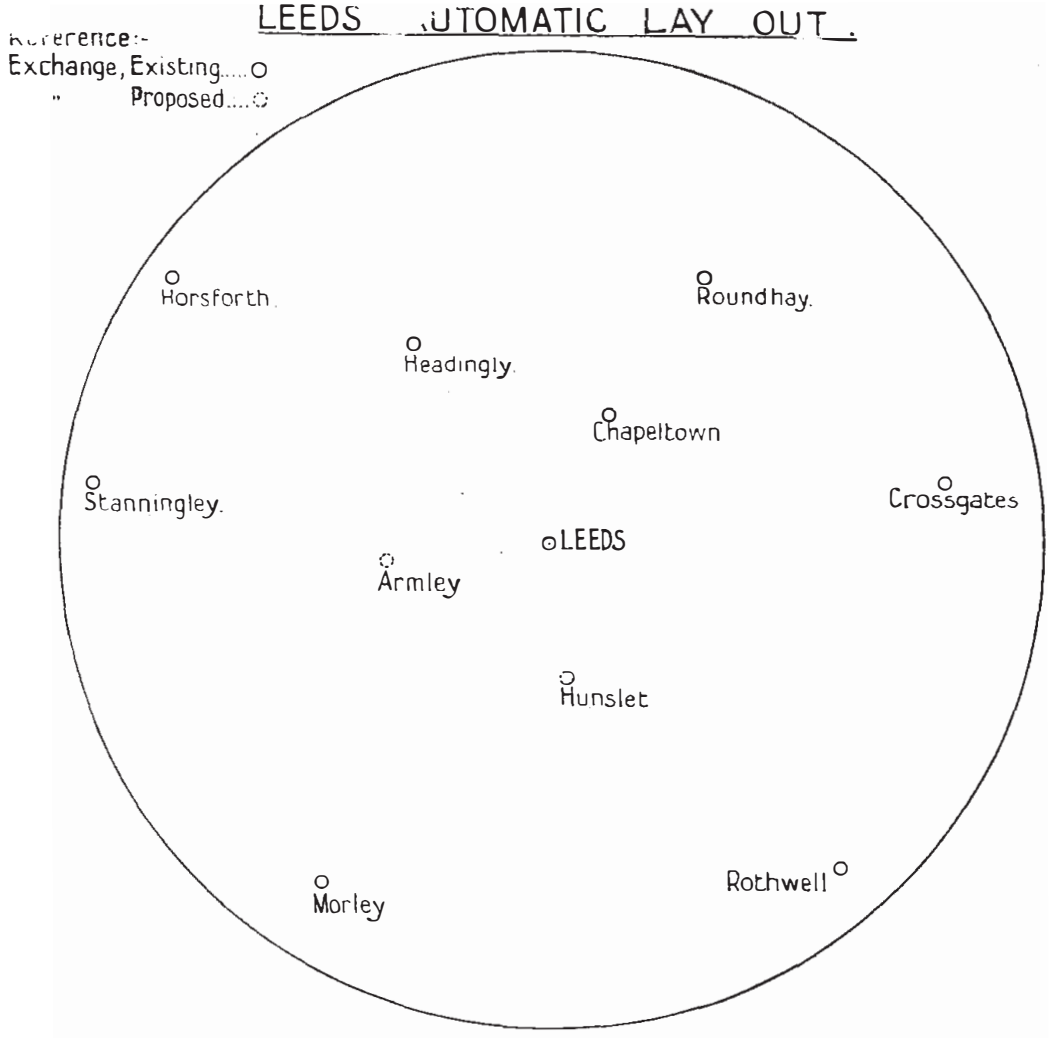


FIG. 1.

May, 1918, that the Leeds Automatic Exchange, representing the first stage of the scheme, was brought into use. The many post-war difficulties have had their effect in delaying the second stage of the scheme until the end of last year.

Fig. 1 shows the existing and projected exchanges within the 5 mile radius from Leeds. A satellite exchange will be opened at

Armley in 1927 to serve subscribers at present connected to Leeds Exchange.

About 1933 it will be economical to open a Satellite to serve the district around Hunslet, which is at present served from Leeds.

The small Exchanges at Crossgates, Horsforth, Morley, and Rothwell will continue to work as Manual Exchanges for several years.

With the Automatic Exchanges now in use, however, approximately 80% of the subscribers in the Leeds area are receiving automatic service.

The present and ultimate equipments of the Leeds Exchange and the four sub-exchanges are :—

	Present.	*Ultimate.*
Leeds	9600 lines ...	14000 lines.
Chapeltown ...	1300 ,, ...	2100 ,,
Headingley ...	1500 ,, ...	2400 ,,
Roundhay	1200 ,, ...	2000 ,,
Stanningley ...	800 ,, ...	1500 ,,

An extension of the equipment at Stanningley is in hand which will bring the present equipment up to 1000 lines. Five figure numbers are in use throughout the area, the scheme of numbering at present being as follows :—

Leeds	20000-29599
Chapeltown	41000-42299
Headingley	51000-52499
Roundhay	61000-62199
Stanningley	71000-71999

The range of numbers 38000-39299 has been allotted to Armley new Exchange, and 34000-35599 has been reserved for the projected Exchange at Hunslet.

The equipment at each of the new exchanges is standard Strowger appartus manufactured by the Automatic Telephone Manufacturing Company, of Liverpool.

Fig. **2** shows the Preselector side of the Line Switch Units at Roundhay.

Fig. **3** shows the Final Selector side of the Line Switch Units at Headingley.

Fig. **4** is a general view of the Chapeltown Exchange showing the Line Switch Units and the Switching Selector Repeater Board.

Fig. **5** shows in the left foreground the Outgoing Junction Preselectors at Stanningley exchange. At the rear are the Switching Selector Board and the 3rd Selector Board.

All exchange equipments are housed in buildings specially designed by the Office of Works for the purposes of automatic telephone exchanges. To meet the developments that are taking place in the residential portion of Leeds, rearrangements of the boundaries of the territory served by several of the sub-exchanges were necessary. These rearrangements tended to complicate the general scheme of transfer, and in view of this it was decided the transfer should be effected at twelve o'clock midnight, when it was expected the traffic would be very light. The scheme of transfer included the following :—

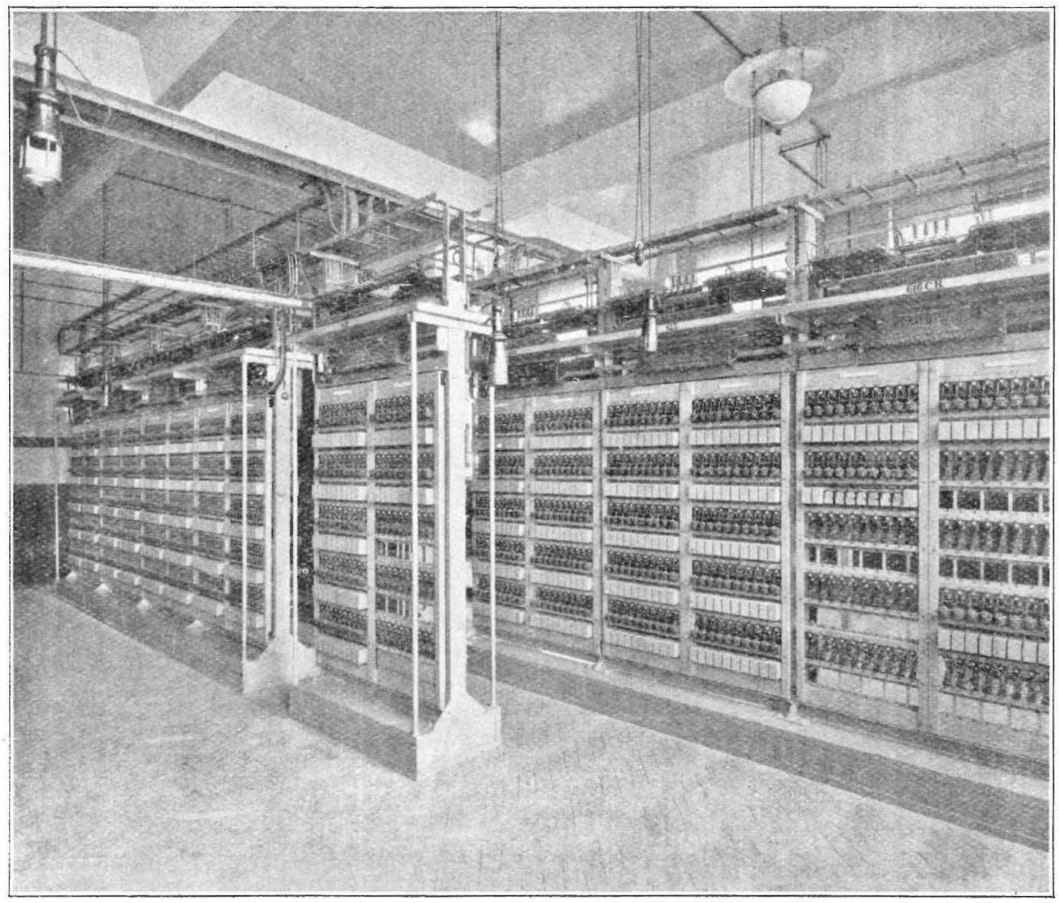


FIG. 2.—ROUNDHAY—LEEDS EXCHANGE. ROTARY LINE-SWITCH UNITS.

(*a*) Conversion of 3,602 subscribers and 553 Junctions to automatic working.
(*b*) Transfer of 147 subscribers from Leeds Exchange to Headingley.
(*c*) Transfer of 21 subscribers from Leeds Exchange to Chapeltown.
(*d*) Transfer of 227 subscribers from Roundhay Exchange to Chapeltown.

(*e*) Transfer of 133 subscribers from Chapeltown Exchange to Roundhay.

(*f*) Rearrangement of circuits at the Leeds Manual Exchange.

(*g*) Rearrangement of Junction circuits at the Leeds Automatic Exchange.

The conversion of the 4 sub-exchanges together with the rearrangements at Leeds Automatic and Manual Exchanges, represent in effect six separate transfers carried out simultaneously. The work required careful organisation and testing out, and the

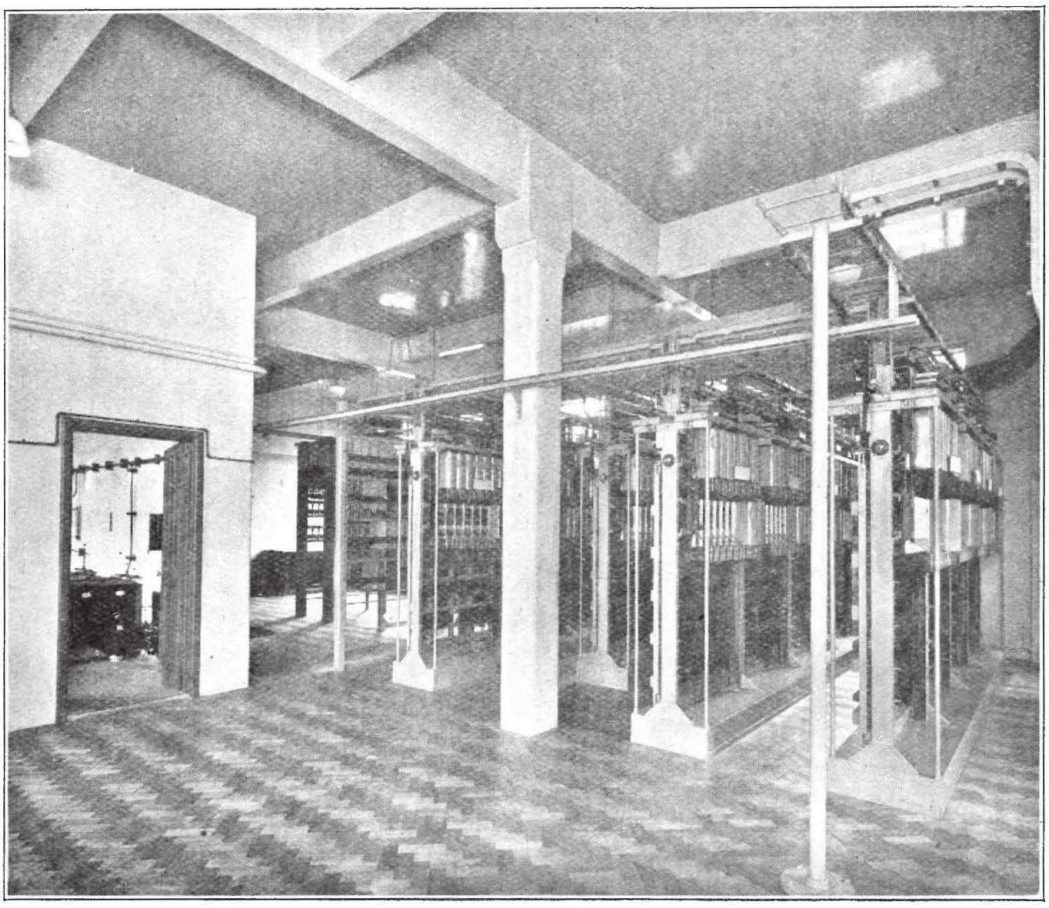


FIG. 3.—HEADINGLEY—LEEDS EXCHANGE. GENERAL VIEW.

smoothness with which the transfer was effected and the compartively few faults experienced, reflects great credit on the local engineering force at Leeds.

As was anticipated, the traffic at midnight was negligible, and this enabled the "permanent loops" due to receivers off, external line faults, etc., to be quickly detected and plugged out at the M.D.F. Up to the time of the transfer the weather had been very bad, with high winds and rain for thirty hours. In spite of this,

however, the number if lines so plugged was only 114, representing 3.1% of the subscribers' lines transferred. In view of the bad weather conditions this may be regarded as very satisfactory.

Each of the exchanges is a satellite on Leeds exchange, and a feature of the switching scheme is the use for the first time in this country of Switching Selector Repeaters.

A Switching Selector Repeater combines the function of an Outgoing Repeater for calls to other Automatic exchanges, with that of a Selector for calls to subscribers on the same exchange. When a subscriber on the Satellite dials a number within the range

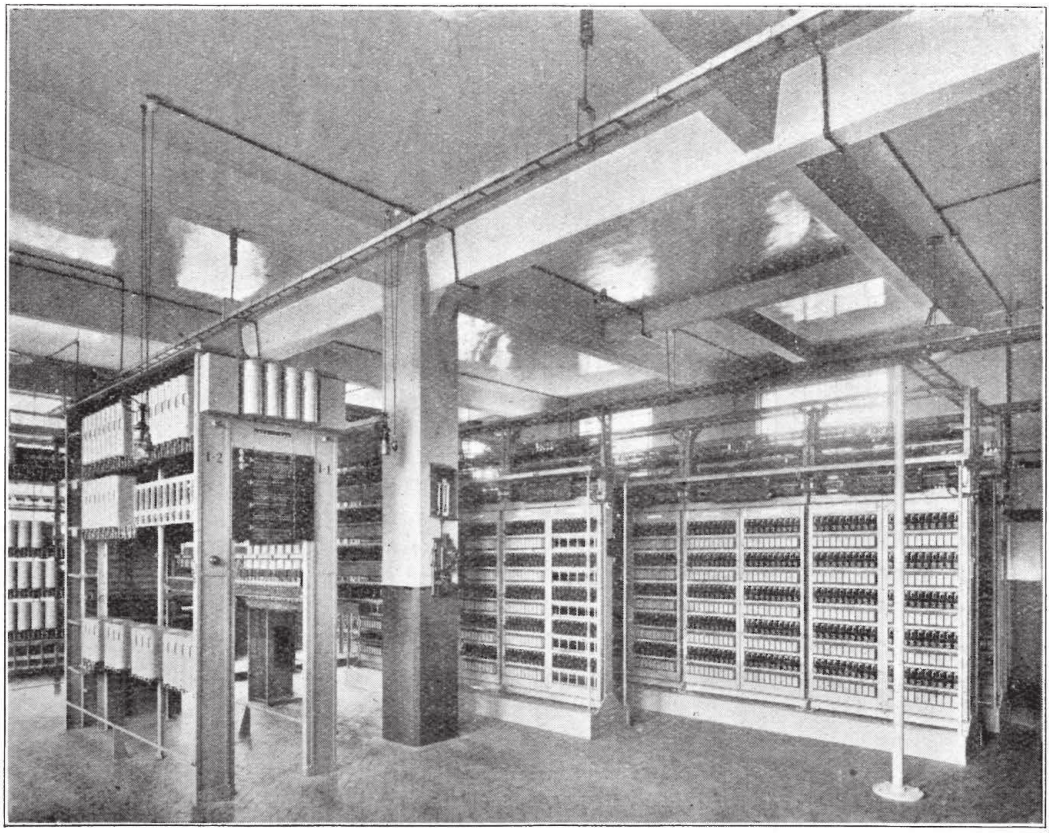


FIG. 4.—CHAPELTOWN—LEEDS EXCHANGE. GENERAL VIEW.

of numbers allotted to that satellite, *i.e.*, a local call, the apparatus acts as a Selector Switch, the Repeater equipment being switched out of circuit. When a number other than a local number is dialled, the apparatus acts as a Transmission Bridge and Impulse Repeater.

With each Selector Repeater is associated a Junction Preselector, which tests for and connects an outoing junction to the Selector Repeater. On all originating calls, therefore, a calling

subscriber on lifting the receiver is connected to a Selector Repeater, and also to a 1st Selector at Leeds Exchange. When dialling takes place the Switching Selector Repeater and the 1st Selector operate simultaneously until the digits which determine whether a call is local or not have been dialled. On local calls, when " switching " takes place the 1st Selector at Leeds is released and the junction and 1st Selector become available to other calling

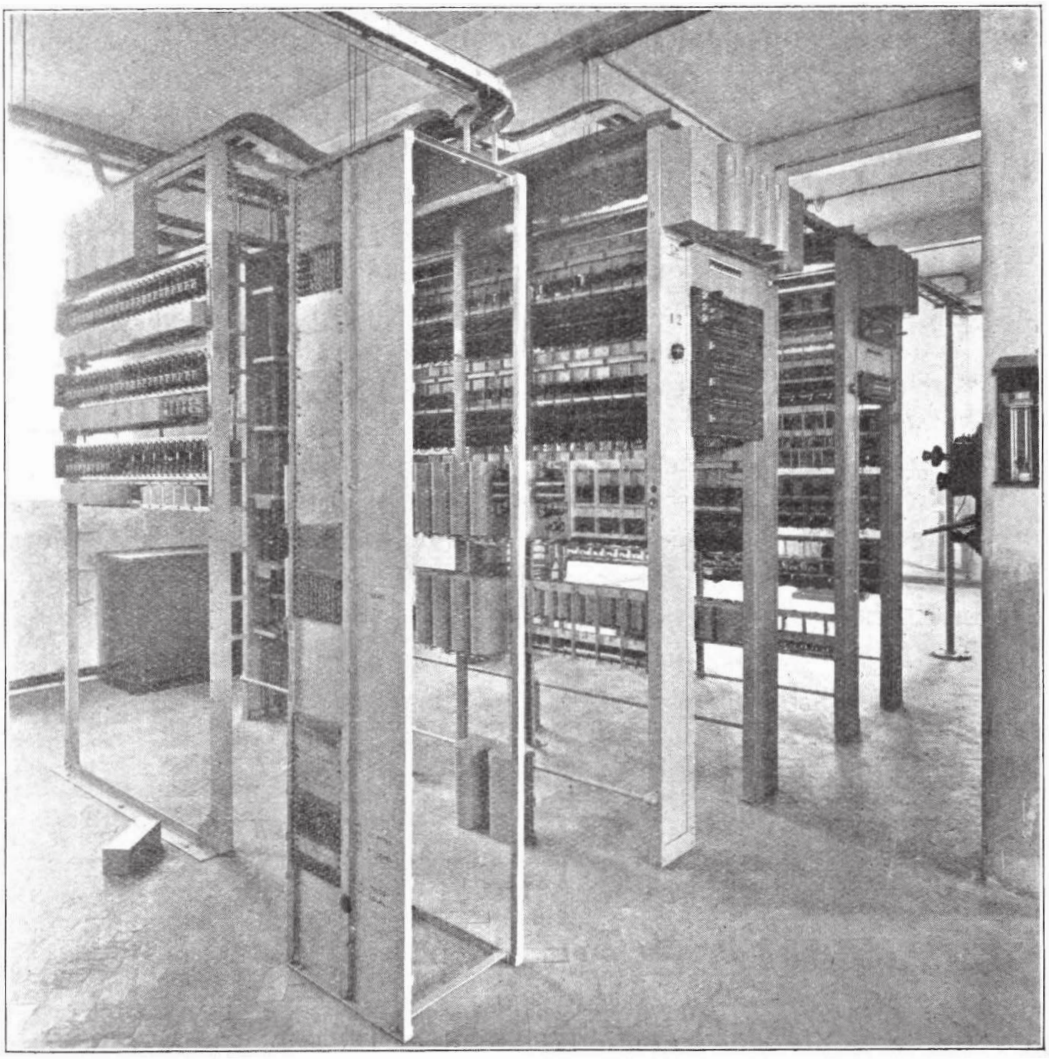


FIG. 5.—STANINGLEY—LEEDS EXCHANGE. OUTGOING SECONDARY LINE-SWITCH RACK AND SELECTOR TRUNK BOARDS.

subscribers. " Switching " may take place on the 1st, 2nd, or 3rd digit according to the numbering scheme, but in the case of the Leeds Satellites the first digit determine whether the call is local or not. A " Digit Absorbing " feature is incorporated in the Switching Selectors to enable them to be used both as 1st and 2nd Selectors on local calls. This special feature consists of a

circuit arrangement which operates the Release magnet and restores the switch to normal after the first digit has been dialled. Assuming the case of a local call, when the initial digit is dialled the wipers of the Selector Repeater are raised to the corresponding level, and are then rotated to the first contact of the level. The Release magnet circuit then operates and the wipers are returned to normal. When the second digit is dialled the Switch functions as a 2nd Selector in the normal manner, and after the wipers have selected a free trunk to the next rank of switches, the Repeater portion of the apparatus is switched out, and the outgoing junction to Leeds Exchange is released. The remaining digits of the number operate the local switches, *i.e.*, the 3rd and Final Selectors. A separate group of circuits is provided for short trunk traffic, so that when 0 is dialled the call is routed direct from level 0 of the Selector Repeaters to the Manual Board. This arrangement makes for economy in external plant, as it is necessary to provide circuits of high grade transmission only for the circuits direct to the Manual Board. The use of level 0 of the Selector Repeaters for direct Manual Board circuits precludes the use of the digit 0 at the second digit in subscribers' numbers, as will be seen from the numbering scheme for the Satellite Exchanges. Fig. **6.** Figs. A to F indicate various methods of routing calls from a Satellite Exchange equipped with Selector Repeaters.

Figs. A and B show the routing of calls *via* 1st Selectors at the Main Exchange, the apparatus acting as a Repeater.

Fig. C shows the routing of calls over direct 0 level junctions. The apparatus functions as a Selector Switch, a special Outgoing Junction Repeater being provided.

Fig. D may be used in 4 figure systems where the number of lines on the Satellite exceeds 1000. The apparatus functions as a 1st Selector.

Fig. E is used on 5 figure systems where the number of lines on the Satellite exceeds 1000. The apparatus functions both as a 1st and 2nd Selector.

Fig. F is used on 5 figure systems where the number of lines on the Satellite does not exceed 900 and where direct 0 level junctions to the Manual Board are provided. The apparatus functions as a 1st, 2nd and 3rd Selector.

Each switching Selector is provided with two "Private" wipers and two contacts on each private level of the bank contacts, these being known as the P1 and P2 wipers and contacts respectively. On levels used for local calls, and the "0" level when direct Junctions to the Manual Board are provided, the contact banks of the Switching Selectors have the +, −, and P2 contacts multipled together. On other levels the contacts are left

SWITCHING SELECTOR REPEATERS

A. T. M. Co's System.

Schematic Diagram of various methods of Routing Calls.

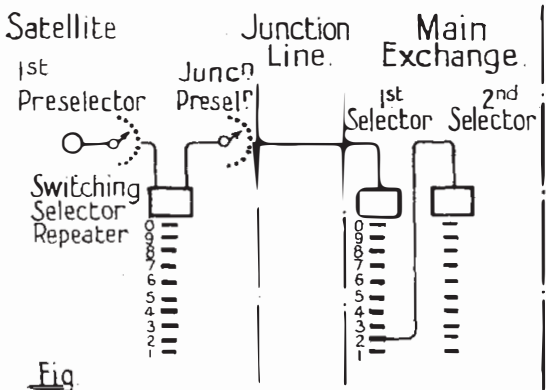


Fig. A. Satellite to Main Auto Exchange

Satellite (Nos 4,000 to 5,999)

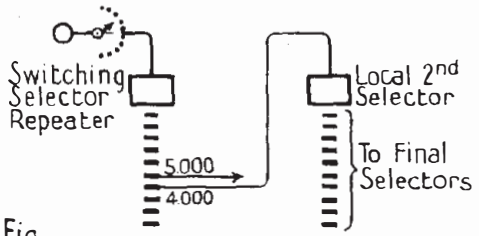


Fig. D. Satellite to Local 2nd Selector Switching on 1st Digit of 4 Figure number

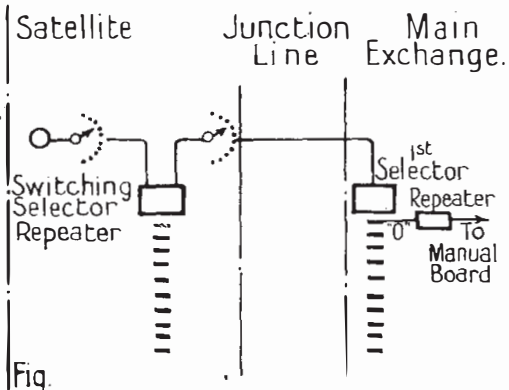


Fig. B. Satellite to Manual Board via Main Auto.

Satellite (Nos 41,000 to 42,999).

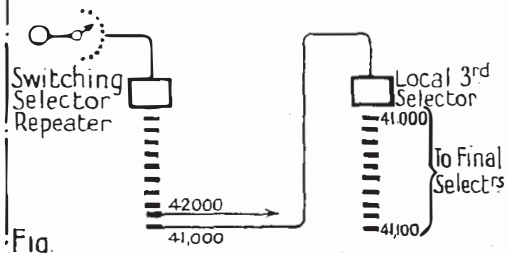


Fig. E. Satellite to Local 3rd Selectors Switching on 2nd Digit of 5 Figure number 1st Digit absorbed.

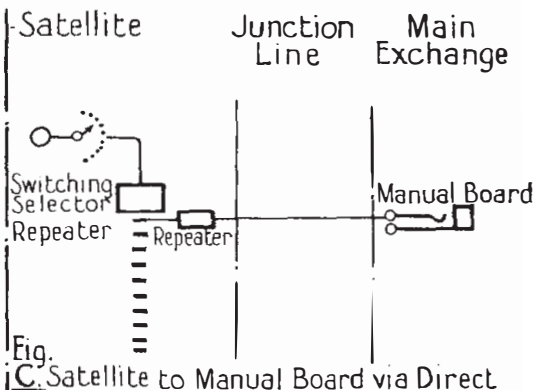


Fig. C. Satellite to Manual Board via Direct Junctions. Switching when 0 is the 1st Digit.

Satellite (41,100 to 41,999).

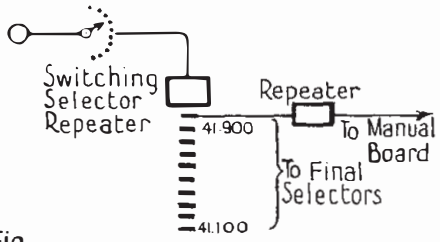


Fig. F. Satellite to Local Final Selectors. Switching on 3rd Digit of 5 Figure number: 1st and 2nd Digits absorbed.

FIG. 6.

unwired, except that the first P1 contact of the level corresponding to the first digit of the local numbers is earthed *via* the Switching Selector Repeater circuit.

Fig. 7 shows a typical bank wiring scheme for a Satellite numbered 41000—42999. When the initial digit 4 is dialled, the wipers are raised to the fourth level and are then rotated to the first contact. The earth on the P1 contact completes the release magnet circuit and the wipers are returned to normal. When the second digits, 1 or 2 are dialled, the switch functions as a 2nd Selector in the normal manner. For calls to other exchanges, the wipers are lifted to the level corresponding to the initial digit, and

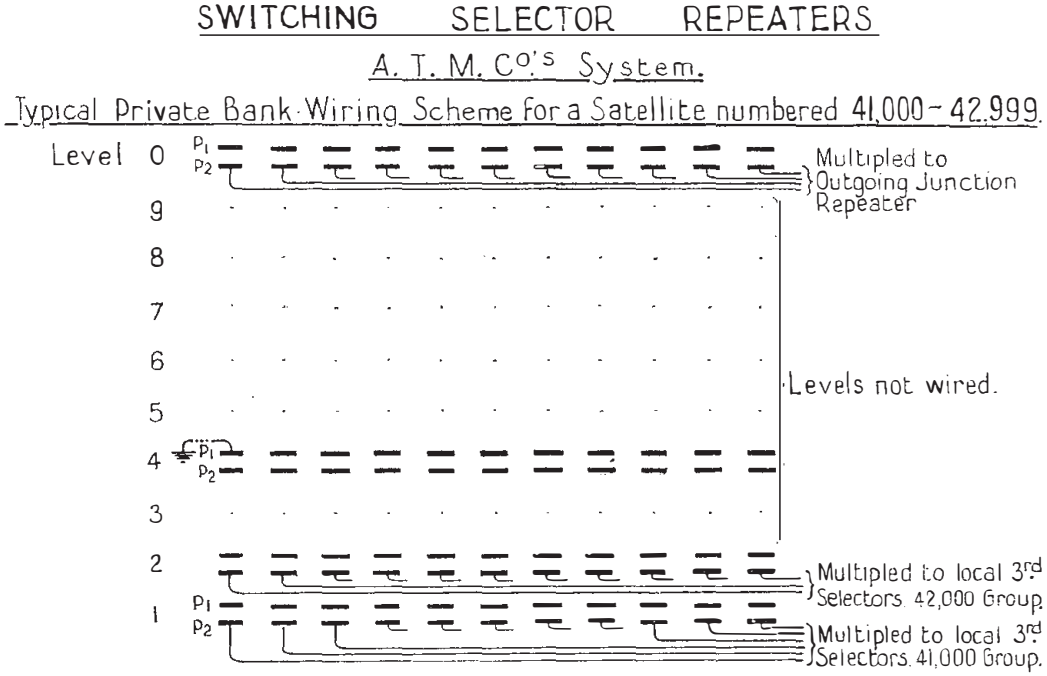


FIG. 7.

remain at that level until the release takes place at the termination of the calls, the apparatus acting as a repeater only, for the remaining digits of the number.

CIRCUIT DESCRIPTION OF CALL TO MAIN AUTO EXCHANGE. FIG. 8.

Selector Repeater. The operation of the subscribers' Line Switch when the receiver is lifted extends the calling line to the Selector Repeater, and the A relay is operated *via* the subscribers' loop.

The A relay operates to—

(1) Prepare a loop to energise the A relay of the 1st Selector at the Main Exchange.

(2) Operate relay B of the Selector Repeater.

Relay B operates to—

(1) Complete Release trunk circuit *via* normal contacts of K to earth.

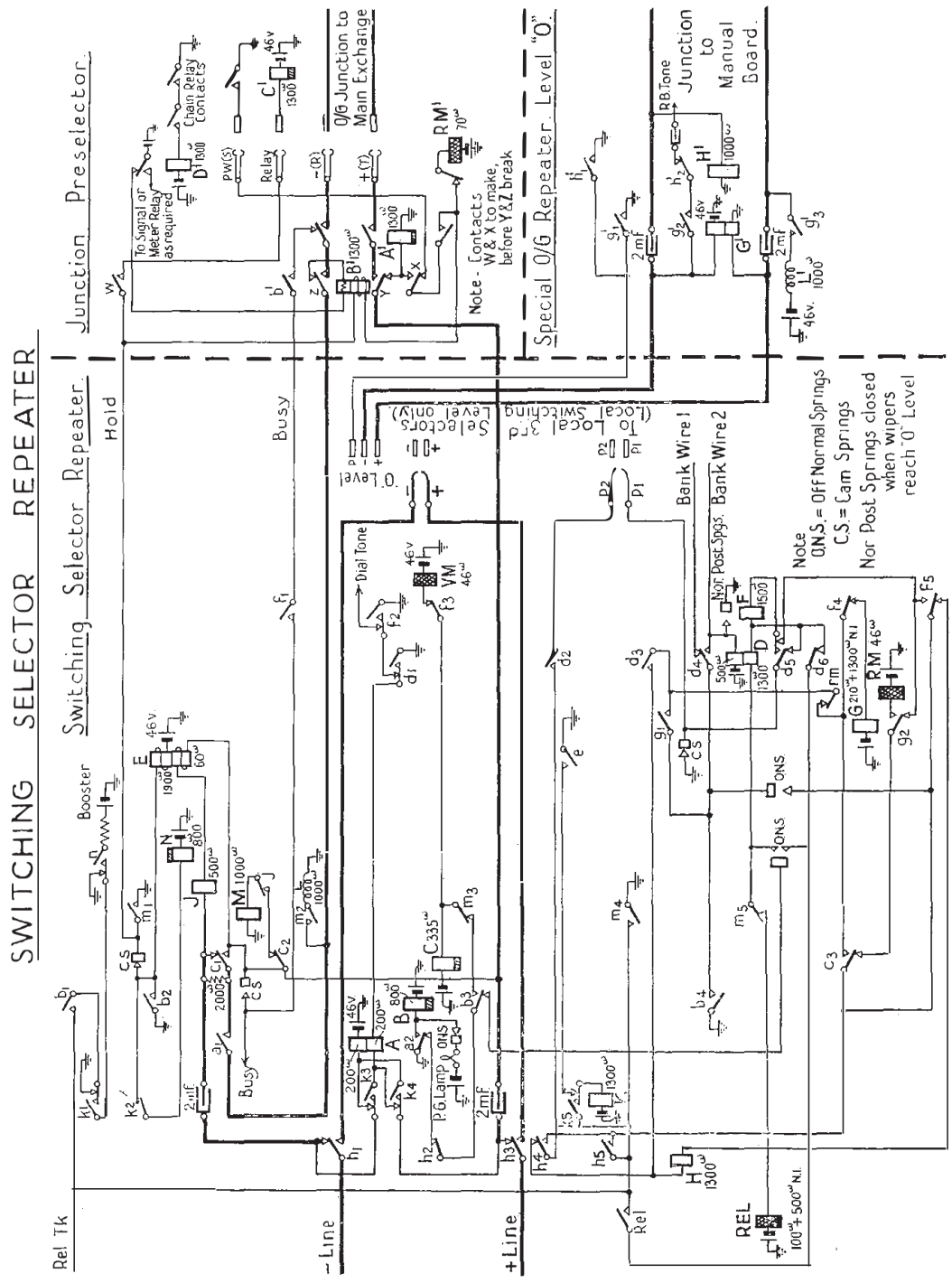


FIG. 8.

(2) Earth the Bank Wire No. 1 *via* normal contacts of D.

(3) Earth "Hold" wire of Junction Preselector *via* normal contacts of cam springs.

(4) Complete the 1900 ohm polarising winding of relay E, which does not operate on this winding alone.
(5) Prepare the circuit of the vertical magnet.
(6) Operate relay N to prepare the metering circuit.

Junction Preselector. The A1 relay of the Junction Preselector operates by battery from normal contacts of D, 300 ohm non-inductive winding of B1, – line, operated contacts of A of the Selector Repeater, normal contacts of C, winding of J, 60 ohm winding of E, + line, winding of A1 to earth. Relay A1 completes a circuit for the Rotary magnet through normal contacts of B1 to PW wiper. Should the Preselector be standing on a busy junction, earth on the PW contact will short-circuit the 1300 ohm winding of B1, and will step the Preselector round in search of a free junction. When a free junction is reached, the PW circuit will be "open" and relay B1 will operate by battery through Rotary magnet to earth at Hold wire.

The operation of Relay B1 of the Junction Preselector—
(1) Switches the + and – lines through.
(2) Complete a circuit *via* the Hold wire for relay C1, which operates and earths the PW circuit, thus making the junction busy.
(3) Completes a circuit for relay A1 which is now held operated by battery through Rotary magnet, operated contacts of A1 and operated contacts of relay B1.

The Rotary magnet will not operate in circuit with the windings of relays A1 and B1 in parallel.

The calling subscriber is now extended over a junction to a 1st Selector in the Main Exchange, which is held operated by the loop circuit in the Selector Repeater previously described, and which will operate in synchronism with the Selector Repeater until after the first digit is dialled. Relay E of the Selector Repeater does not operate at this stage as the current through the 60 ohm winding opposes that in the 1900 ohm winding.

Impulses Received. When the first digit is dialled, relay A of the Selector Repeater falls back at the first break of the dial springs, and a circuit is completed for the vertical magnet through normal contacts of relays F and M, operated contacts of B, normal contacts of H, to earth at A. Relay C also operates in parallel with the vertical magnet and remains operated during the train of impulses. The vertical magnet operates each time the A relay falls back, and lifts the wipers to the level corresponding to the digit dialled.

The C relay operated to—
(1) Prepare the circuit of relay G.

(2) Disconnect relay M from the + line.

(3) Open the circuit through relay J and the 60 ohm winding of E, and substitute a direct loop to the 1st Selector at the Main Exchange. A 2000 ohm non-inductive resistance is bridged across the – line contacts of C to prevent the Selector Switch ahead being given a false impulse during the operation of C.

At the first vertical step of the Selector Repeater, the off-normal springs operate to—

(1) Complete the circuit of relay G, which operates through normal contacts of F, operated contacts of C, off-normal springs, to earth at operated contacts of B.

(2) Prepare the Release magnet circuit.

(3) Short-circuit the 1300 ohm winding of D.

Relay G operates and locks up *via* normal contacts of F, normal contacts of Rotary magnet, operated contacts of G, operated contacts of B to earth, in order to prepare the circuit for the first rotary step.

At the completion of the dialling of the first digit, relay A remains held by the subscribers' loop and opens the circuit of relay C which releases and

(1) Restores the circuit through relay J and the 60 ohm winding of E to the switch ahead, which remains held through the windings of these relays.

(2) Operates the Rotary magnet *via* operated contacts of G, normal contacts of C, off-normal springs, to earth at operated contacts of B.

Rotary Motion. The Rotary magnet operates and

(1) Steps the wipers on the first bank contact.

(2) Opens the circuit of relay G which releases.

The release of relay G

(1) Opens the Rotary magnet circuit, thus allowing the wipers to remain on the first contact of the level dialled.

(2) Operates relay F by battery through release magnet normal contacts of M, off-normal contacts, normal contacts of D, winding of F, normal contacts of D and G, normal contacts of C, off-normal contacts, to earth at operated contacts of B. The release magnet does not operate in series with F.

The operation of F breaks the circuit of relay G and also the vertical magnet, thus preventing any further impulsing on the Selector Repeater.

Any further impulses to complete the required number will be repeated by relay A to the selectors at the Main Exchange.

Metering a Call. When the called subscriber answers, the current flow over the junction through the 60 ohm winding of E will be reversed, and as the two windings now assist each other, relay E will operate to

(1) Complete the circuit to operate relay K, which then locks to earth at release trunk.

The operation of relay K—

(1) Completes the booster battery circuit *via* operated contacts of N, operated contacts of K and B, to release trunk and subscribers' meter.
(2) Open the circuit of N, which releases slowly.
(3) Reverses the current to the calling subscriber.

Relay N being slow to release, holds its contacts long enough for one metering impulse to be given to the subscriber's meter, and when finally released connects earth to the release trunk.

Release. When the called subscriber restores the receiver, relay A is released to

(1) Open the loop across the junction line, thus releasing the switches at the Main Exchange.
(2) Release relay B.
(3) Prepare circuit of release magnet.

Relay B restores and completes release magnet circuit, which now operates by a circuit through normal contacts of M, off-normal springs, normal contacts of B, H and A.

The operation of the release magnet returns the switch to normal and maintains earth on the release trunk *via* the off-normal springs until the switch has actually returned to its normal position.

The release of the Selector Repeater removes earth from the "Hold" wire of the Junction Preselector, thus releasing the A1, B1, and C1 relays of that switch. Relays A1 and C1 release slowly and maintain a circuit for the rotary magnet *via* the normal contacts of B1 for a sufficient length of time to allow the switch to rotate to the next free junction. This is done, so that should the first junction selected be faulty, the calling party on making another call would not be connected to the same junction.

All Outgoing Junctions Busy. If, when a call is made, all the outgoing junctions are busy, the calling subscriber will receive the busy tone after dialling the first digit.

The C1 relay of each Junction Preselector when operated prepares a portion of a circuit to operate relay D1, and when all C1 relays in the group are operated, relay D1 operates to disconnect battery from the 300 ohm non-inductive winding of the B1 relays, thus preventing the operation of the A1 relays. When a call is

originated, therefore, the B1 relay will be operated immediately the "Hold" wire is earthed at the Selector Repeater.

When the first digit has been dialled, relay F of the Selector Repeater operates as previously described, and completes the busy tone circuit. Busy tone is now given to a calling subscriber *via* operated contacts of relays F and B1, normal contacts of A1, operated contacts of B1, to negative line.

Circuit Description of a Local Call.

Call to a Local Number—1st Digit Dialled. The circuit operation of the Selector Repeater is as previously described up to the stage when the vertical impulses cease and the switch rotates to the first bank contact of the level corresponding to the digit dialled.

Assuming that the first digit of the local number is 4, the first P1 contact of level 4 will be connected to earth *via* bank wire No. 1, normal contacts of relay D, to earth at operated contacts of B. When the wipers reach the P1 contact, a circuit is completed for the release magnet *via* normal contacts of M, off-normal contacts, normal contacts of D, wiper P1, bank contact P1, bank wire No. 1, upper normal contacts of D, to earth at operated contacts of B. Relay D will not operate at this stage as the 1300 ohm winding is short-circuited through the off-normal contacts. Relay F is also short-circuited by the earth at the P1 contact. The release magnet operates to release the switch and to provide a locking circuit for itself *via* the off-normal contacts to earth at the release trunk to ensure that release takes place and also to operate relay D by its 1300 ohm winding.

When the shaft returns to normal, the off-normal contacts are broken, and

(1) Removes short-circuit from 1300 ohm winding of D.
(2) Disconects earth *via* P1 wiper from release magnet.

Relay D now operates in series with the release magnet to

(1) Lock up through its 500 ohm winding to earth at operated contacts of relay B.
(2) Open the circuit of its 1300 ohm winding.
(3) Disconnect earth from bank wire No. 1 and private wiper P1.
(4) Prepare a short-circuit on relay H.
(5) Disconnect Dialling Tone from subscriber's line.

Second Digit Dialled. When the second digit is dialled, the operation is as previously described except that immediately the switch steps off normal and relay G operates, the short-circuit on

relay H is completed *via* off-normal springs, operated contacts of relays D and G, and normal contacts of relay F.

When the impulses cease, relay C releases and operates the rotary magnet as previously described.

Rotary Motion. If the first trunk is engaged, the P2 contact will be earthed. Relay G after releasing when its circuit has been opened by the rotary magnet interrupter springs, will operate again *via* the earth on P2 contact. The earth on P2 also maintains the short-circuit on relay H, in order that it shall not operate until a free trunk is found. The wipers are thus stepped round until a free trunk is found or until they pass off the 10th contact.

All Trunks Busy. The wiper shaft at the 11th rotary step operates the cam springs, which

(1) Opens the "Hold" trunk to the Junction Preselector, releases the junction and consequently the 1st Selector at the Main Exchange.
(2) Places busy tone on the line to the calling subscriber.
(3) Operates relay F by battery through release magnet, 1300 ohm winding of relay D, winding of F, operated contacts of D, to earth at cam springs.

Relay F operates to open the circuit of relay H and thus prevent release of the Selector until the calling subscriber restores receiver.

Free Trunk Found. If a free trunk is found, relay G on restoring after its circuit has been opened by the rotary magnet interrupter springs, removes the short-circuit from relay H, which operates in series with relay G *via* normal contacts of F, rotary interrupter springs, operated contacts of D, winding of H off-normal springs, to earth at operated contacts of B. Relay G does not operate in series with H.

The operation of relay H—

(1) Extends the calling line to the next rank of switches.
(2) Extends the release trunk to private wiper P2 *via* operated contacts of D.
(3) Opens the circuit of relays A and B, which release and open the circuit to the Junction Preselector and to the 1st Selector at the Main Exchange.

Remaining Digits. The remaining digits operate the switches ahead in the normal manner. Operation of the calling subscriber's meter is effected by the final selector.

Calling Subscriber Clears. When the calling subscriber restores the receiver, the release of the relays in the Final Selector removes earth from the release trunk, thus releasing relay H. The

release of H completes the circuit for the release magnet, and release then takes place in the usual manner.

Calls to Manual Board Direct from Selector Repeater. The operation of the Selector Repeater when 0 is dialled as the initial digit, is as described for local calls except that when the wipers reach the tenth level the "Normal Post" springs operate to complete a circuit for the 500 ohm winding of relay D. Relay D operates to

(1) Disconnect dialling tone.
(2) Allow relay H to operate in series with relay G, and thus extend the subscriber's loop and the release trunk to the Special Outgoing Repeater.

Relay G1 of the Special Repeater operates *via* the calling subscriber's loop, and

(1) Earths release trunk.
(2) Connects audible ringing signal to calling subscriber.
(3) Completes circuit of Retard Coil L1 of Repeater *via* B line of junction to line relay at Manual Exchange.

Operator Answers. When the answering plug is inserted in the answering jack, battery from the ring side of the plug passes over the A line of the junction to operate the H1 relay of the Repeater. Standard supervision is given to the operator by the calling subscriber, but it will be seen that so long as the answering plug is in the jack, relay H1 is held operated to maintain earth on release trunk and prevent the subscriber from releasing the connection. The operator thus controls the connection.

Calls to Manual Board via Main Auto Exchange. The Selector Repeater is designed to give similar control when calls are made *via* the 1st Selector at the Main Exchange. When, say 91, is dialled, the 1st Selector at Leeds extends the line through a Special Repeater to the Manual Board.

The loop *via* relay J and the 60 ohm winding of E in the Selector Repeater, completes a circuit for the line relay in the Special Repeater at the Main Exchange and the calling lamp lights. When the operator inserts the answering plug, the Special Repeater connects battery to both the + and − line of the junction. The effect of this is to de-energise relay J of the Selector Repeater. The release of relay J completes a circuit for relay M, which operates by battery over the + line.

The operation of relay M—

(1) Earths the release trunk.
(2) Earths "Hold" trunk to Junction Preselector.
(3) Connects retard L to the − line.
(4) Breaks release magnet circuit.

Standard supervision is given to the operator, and the subscriber cannot release the connection until the answering plug is withdrawn and relay M released.

The equipments were manufactured and installed by the Automatic Telephone Manufacturing Co., Liverpool, to whom we are indebted for the photographs illustrating the article.

TIME SAVING TESTERS.

FOR AUTOMATIC EXCHANGES.

By W. PRICKETT AND H. S. SMITH.
(Engineer-in-Chief's Office).

AUTOMATIC exchange plant, installed for the Department by contractors, is subjected before acceptance to a series of tests. In the April 1925 issue of this Journal, a brief survey of these necessary preliminary tests was made and a promise was given that they would later be described in greater detail. The present article is the first of a series intended to fulfil that promise.

Formerly the tests were made by the ordinary manual method. But this was slow and not so reliable as it might be and in 1923, when it came into competition with the new method of automatic testing, it was definitely relegated to second place. During the installation of the L.C.C. P.A.B.X., in the County Hall, Westminster, which was the first of the series of exchanges installed for the Department to be equipped with the now standard rotary type of line switch, the testing was begun by the old manual method, but the opportunity was taken of trying out an automatic tester (described later in the article) and of comparing the result. As an Irishman might say, there was no comparison. The automatic method at once took and still keeps the lead, although the manual method is still used for tests for which automatic methods have not yet been devised.

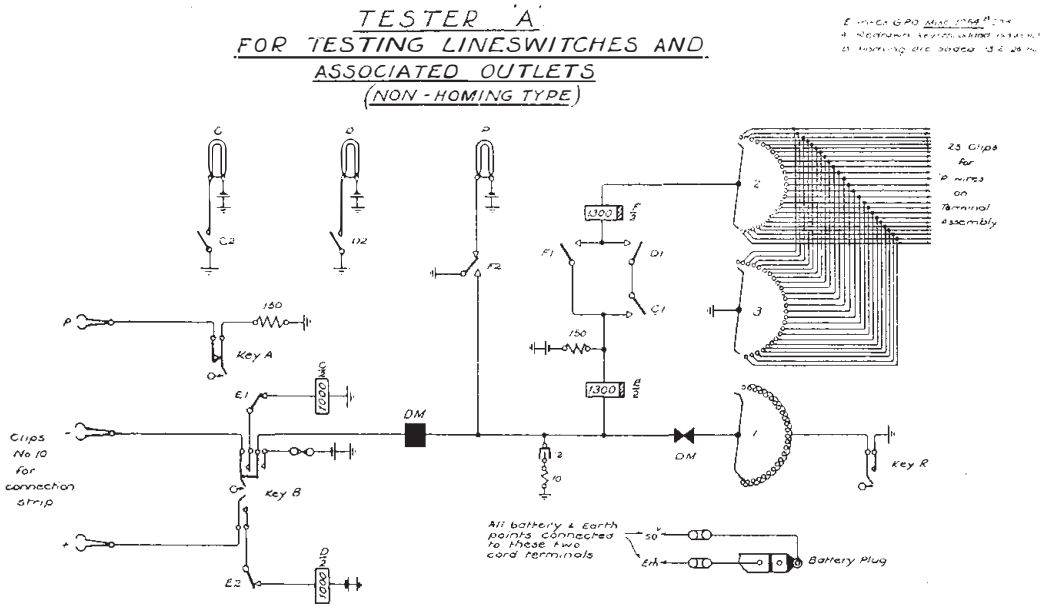
Tester "A," used on this occasion has now only an historical interest, but it is worth describing in some detail as an introduction to the later and improved apparatus, the underlying principles of both being similar.

Arrangements have been made for each of the sets of apparatus required for the tests to be permanently associated on suitable mountings, and enclosed in a protective case, the whole being known as a "tester" and being supplied complete to the exchange concerned.

Tester "A."

For Testing Line Switches (non-homing type) and Associated Outlets.

Line switches, in common with all other automatic switches, should be closely watched for satisfactory mechanical operation.


TESTER 'A'
FOR TESTING LINESWITCHES AND ASSOCIATED OUTLETS
(NON-HOMING TYPE)
25 Clips for P wires on Terminal assembly
Key A
Key B
Key R
DM
Clips No 10 for connection strip
All battery & Earth points connected to these two cord terminals
Battery Plug

In addition, it is required to verify that:

(1) The cut-off relay ("BCO") operates when the "busy" condition is applied to the "P" wire of the circuit on the subscribers' multiple;

(2) An originating call causes the line switch to hunt for and seize the first available disengaged outlet;

(3) When the latter has been found the subscriber's line is extended to a first group selector and the multiple made "busy" against incoming calls.

Tester "A," the circuit of which is shown in the sketch, is operated as follows:—

The wipers of all the line switches to be tested are set to contacts No. 1. The tester is connected to the switch under test by means of the three clips "−," "+" and "P," which are attached to the appropriate tags on the unit I.D.F. jumper strip. In cases, however, where the jumpers are in position and provided that the lines on a unit are all in the same group the connection may be made *via* the wipers of the test final selector, which is stepped round by hand to each of the 100 lines on the unit as required.

There are, in addition, twenty-five clips for making contact with the " P " wires of the outlets from the bank. These are numbered from " 1 " to " 25 " and are connected accordingly, on the outlet terminal assembly.

The battery plug is inserted in the unit power jack and the test may then be commenced.

At this stage, no keys are thrown and it will be seen from the diagram, therefore, that earth through 150 ohms is connected *via* key A normal to the P wire. This should operate the BCO relay. To prove that the calling conditions have thus been removed, key B is now thrown, connecting relays C and D to the – and + lines. Should either of these relays operate, the corresponding lamp will glow to indicate the existence of a fault.

If no lamp glows, key R is operated to set the tester preselector to its starting position. The circuit is from Earth *via* R operated, homing arc, DM contacts normal, driving magnet DM, key B operated to battery. The driving magnet will operate, breaking its own circuit each time until the preselector wipers reach contacts 1.

Key A is now operated, thus releasing the BCO relay and restoring the calling conditions to the – and + lines.

A circuit is now complete from battery, *via* line relay, – line, key B operated, E1 normal, and relay C to earth. This should cause the calling relay of the line switch to operate. As the wipers of the latter, however, are resting on disengaged contacts, no rotation should take place and the subscriber's circuit should be extended to the first outlet, on which the selector should be seized. The operation of tester relay C should then be maintained *via* the – line and one coil of the selector relay A to battery.

Relay D in the tester, the battery on which would cause it to operate in the first place *via* E2 normal, key B operated, + line to earth at the line switch, should now remain operated *via* the + line and the other coil of the selector relay A to earth.

If the selector concerned accepts the call correctly, it will now return earth *via* the P wire to maintain the operation of the BCO relay. This earth completes a circuit from battery *via* 150 ohm spool, C1 operated, D1 operated, relay F, and wiper 2 of tester preselector, contact 1 and P clip 1.

Relay F, operating, locks *via* its own contact F1 to battery and applies earth at F2 operated to battery *via* key B operated and the driving magnet. The latter operates, but the wipers do not move forward. Relay E is also operated from battery *via* 150 ohm spool.

The operation of relay E disconnects relays C and D, which release at E1 and E2 operated, and so removes the calling con-

ditions from the selector relay A. The latter, releasing, should in turn cause relay B to release and remove the earth from the P wire. On the removal of this earth, the locking circuit of relay F is broken, and this relay releases, but as it is slow releasing time is allowed for the BCO relay to restore the line switch calling conditions in readiness for the next test, before the earth is removed at F2 normal from the driving magnet. The latter now steps forward and prepares the circuit of F at wiper 2 for testing the P wire of the second outlet, and also places a busy earth on the P wire of the first outlet *via* wiper 3 and contact 2, in order to ensure that the line switch will be tested for rotation over an engaged outlet. As the reader will no doubt be aware, the wipers of the non-homing type line switch normally remain on the contact last used.

When relay F released, the earth was also removed from relay E which is also slow to release. In due course then, relay E releases and restores the calling circuit to relays C and D at E1 and E2 normal.

The sequence of operations is now repeated, but as outlet 1 is busy, the line switch, operating, should step forward to outlet 2 and seize the selector connected thereon.

When outlet 2 has successfully been tested, it is busied in turn and the test proceeds on outlet 3 and so on until all outlets have been tested.

As each line switch is equipped with a double set of wipers it is necessary to make two sets of tests on the outlets. The line switch, therefore, should be stepped on to contact 1 again when it comes to rest on contact 25, and the tester should be allowed to proceed until the requisite fifty tests have been completed, when keys A and B should be released and the −, + and P clips rmoved to the next subscriber's line switch.

Each time an outlet is seized during the progress of the tests, the " PG " lamp of the associated selector will glow for a short period. A convenient means is thus available for checking the order in which the selectors are engaged, against the switch designation shown on the outlet chart. In addition, a rough test is afforded for contacts between adjacent − or + lines, as a fault of this nature will cause the simultaneous operation of more than one switch.

The circuit of the tester is arranged so that faults of various kinds cause the sequence of operations to be suspended. Observation of the lamps provided will afford some indication as to the portion of the circuit affected, and to some extent the nature of the fault, although the requirements are merely that its existence shall be indicated.

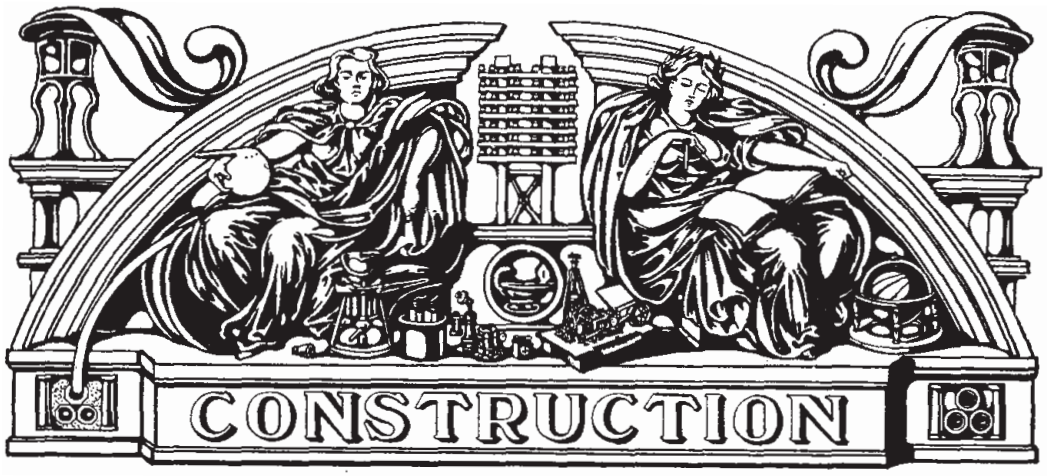
The appended schedule gives a brief indication of some of the conditions which are found when wiring faults are present. Other faults, such as apparatus defects, may also be detected, either by observation of the switches or by the tester.

A comparison of results reveals that the tests on a unit of 100 line switches, which formerly occupied two men for four hours, can now be carried out by one man in one hour. In addition, the reduction of the human factor minimises errors and reduces fatigue.

Other testers will be described in further articles of the series.

SCHEDULE OF FAULT INDICATIONS.

Nature of Fault.	Location.	Wire.	Keys operated.	Lamps		Tester Preselector stops on Contact.
				Glowing.	Not Glowing.	
Dis.	Line switch	−	A B	D P	C	1
		+	A B	C P	D	1
		P	B	Tester proceeds without operation of Key A.		
	Outlet	−	A B	D P	C	Line switch also chatters. Connected to Faulty Outlet.
		+	A B	C P	D	
		P	A B	C D P	—	
Contact	Line switch	− & +	B	—	C D P	1
		− & P	B	D P	C	1
		+ & P	B	D P	C	1
	Outlet	− & +	A B	P	C D	Connected to Faulty Outlet.
		− & P	A B	D	C P	
		+ & P	A B	—	C D P	
Reversal	Line switch	− & +	A B	P	C D	1
		− & P	B	D P	C	1
		+ & P	B	C	D P	Test proceeds without Key A being operated.
	Outlet	− & +	A B	P CD flash		Line switch chatters. Connected to Faulty Outlet.
		− & P	A B	P		
		+ & P	A B	—	C D P	
Earth	Line switch	−	A B	D	C P	1
		+	B	C D P	—	1
		P	A B	P	C D	1
	Outlet	−	A B	—	C D P	Connected to Faulty Outlet.
		+	A B	C D P	—	
		P	A B	—	C D P	



GUILDHALL EXCHANGE TUNNEL.

It would be hard to find a site in London more difficult to reach with underground conduits than that in Wood Street, E.C., on which the Guildhall Exchange will stand. Wood Street is in the centre of that warren of narrow thoroughfares which has existed since the Roman occupation. The Romans must have used it when they built old London Wall. By the 13th century it had acquired some importance and is clearly shown on old maps which purport to show what London was like in those days. It is still so narrow that it is doubtful if its general outline has changed during the past seven centuries.

In this area, however, one must not judge the importance of a street by its width. It is in Wood Street that many of the great "soft goods" merchants of London have their headquarters, for it is the centre of what is irreverently termed the "Rag" trade. Why people in a similar line of business should huddle close together is a social phenomenon that has never been satisfactorily explained; there seem to be as many reasons why they should repel as attract each other, but, whatever the explanation, the fact that such congregation does take place is demonstrated before one's eyes. They get as close together as possible, and there is so small a space to hold them all that in order to make the most of what room there is the buildings have to go skywards. The buildings are all substantial and well built, and have an air of commercial solidity that apart from the famous names that appear on them would create confidence.

During the daytime Wood Street is choked with traffic. To have laid ducts by surface excavation, had that course been open to us, would have completely blocked the street. There were,

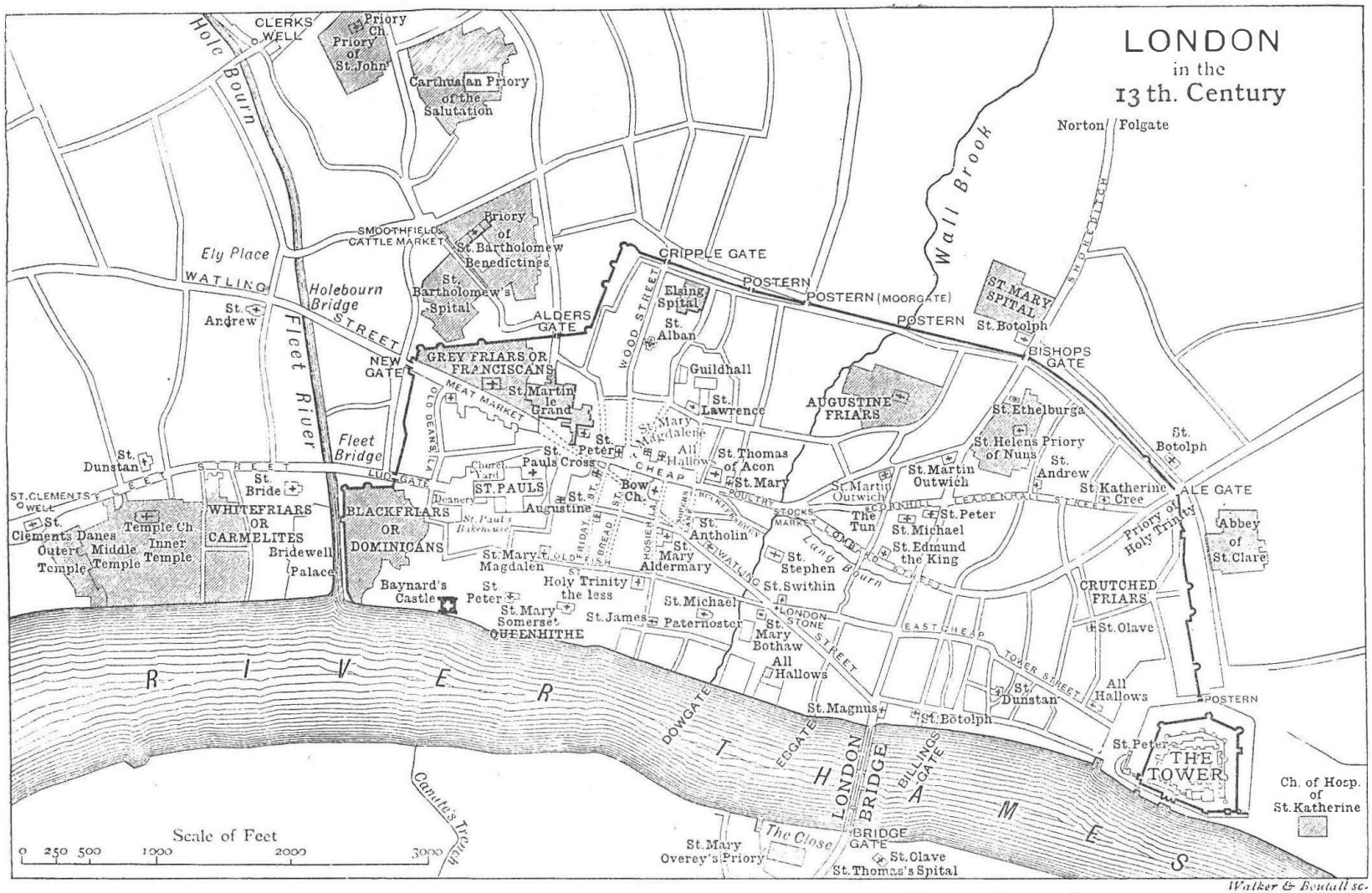


FIG. 1.—MAP OF LONDON FROM GREEN'S "SHORT HISTORY OF THE ENGLISH PEOPLE."

however, other reasons which prevented that method being seriously considered. The mains of many public utility undertakings are already under the street and occupy all the available space to a considerable depth. Still deeper, at approximately 14 ft. from the surface, is a large sewer six feet in diameter; there was therefore not sufficient space for the conduits except by going below the sewer. Under the sewer at a depth of rather more than 20 ft. there is a stratum of wet sand and ballast. In some places this waterlogged ground is as much as 9 ft. in thickness before the famous blue clay of London is reached. The difficulties would

FIG. 2.—WOOD STREET, CHEAPSIDE.

have been greatly increased if we had gone through this wet ground, and a route through the solid blue clay was clearly the one to adopt.

If there had been none of these difficulties the conditions laid down by the City authorities would still have made it necessary to construct a tunnel. One of the stipulations was that we were not to open up either Wood Street or London Wall. The exchange site was, therefore, the only place on which an opening

could be made. Through an excavation at this spot practically the whole of the tunnelling operations were carried out.

Both Wood Street and London Wall are in the area known to the Fire Brigade authorities as the Danger Zone, and if there had been no other reason this alone would have been sufficient to have caused the City Corporation to refuse to allow the streets to be obstructed.

The development figures required provision for at least 60 cables to be made along Wood Street and 48 cables along London

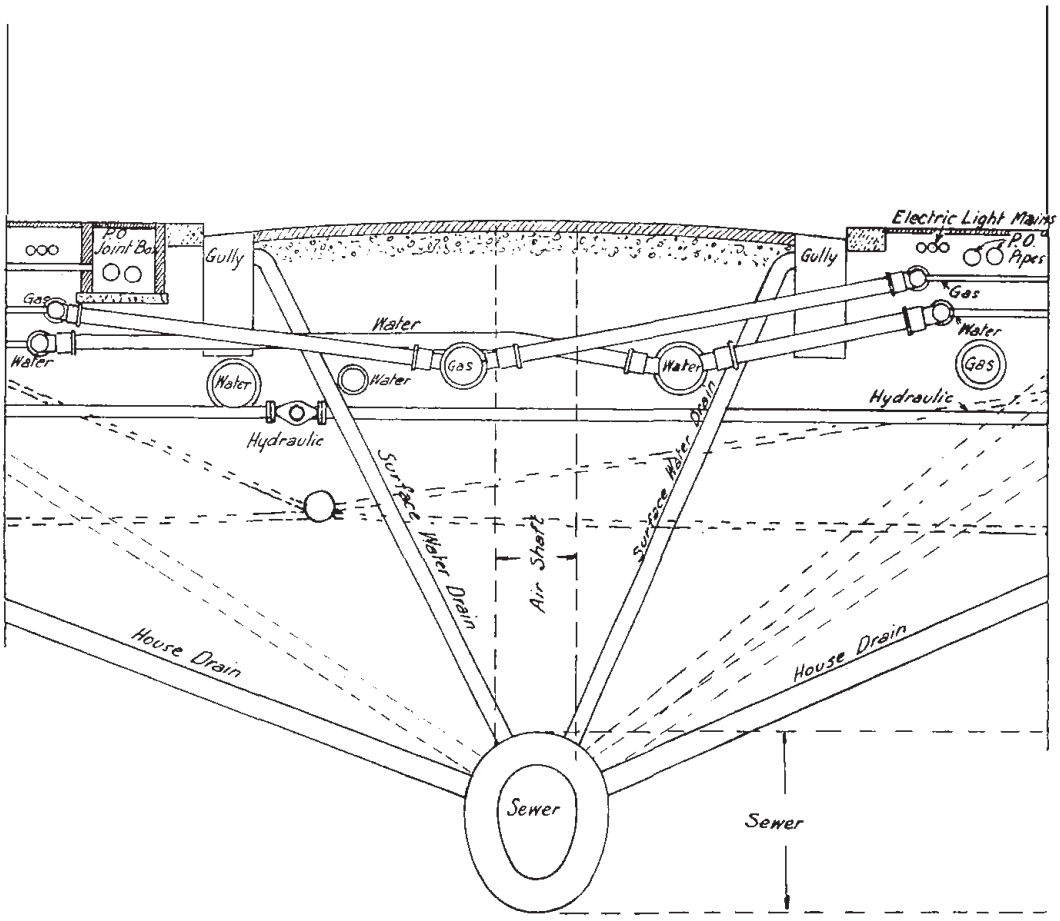


FIG. 3.—SECTION SHOWING PLANT UNDER WOOD STREET TO SEWER LEVEL.

Wall. Three ways of meeting these requirements were considered. The first was to construct a tunnel and fill it with octagonal ducts; the second, to build a brick subway and support the cables on bearers; and the third, to construct a tunnel built of cast iron sections like a miniature tube railway.

For what now appear to be quite obvious reasons the first and second proposals were soon ruled out. The first method, under the conditions which have previously been mentioned, would have involved the excavation of the whole of the tunnel, before the ducts

could have been laid. A brickwork tunnel could have been carried along as the excavations were being done but only at great inconvenience. Further, it would have involved an enormous amount of timbering to hold up the excavation. The City Authorities require all supporting timbers to be drawn after the permanent work is done, and the ground filled in solid. Further, a brick tunnel could only have been built at an expenditure much greater than that actually incurred. Apart from that vital consideration a brick tunnel can rarely be made completely watertight.

FIG. 4.—BORING IN PROGRESS.

Before a decision to provide a cast iron tunnel was finally reached many knotty points had to be settled. First of all it had to be agreed that we had the necessary statutory powers to construct a tunnel. When that was out of the way the conditions governing the construction of tunnels were reviewed. It was obvious that work of this kind, to be carried out at a considerable depth, in narrow streets, the width of which made it necessary to

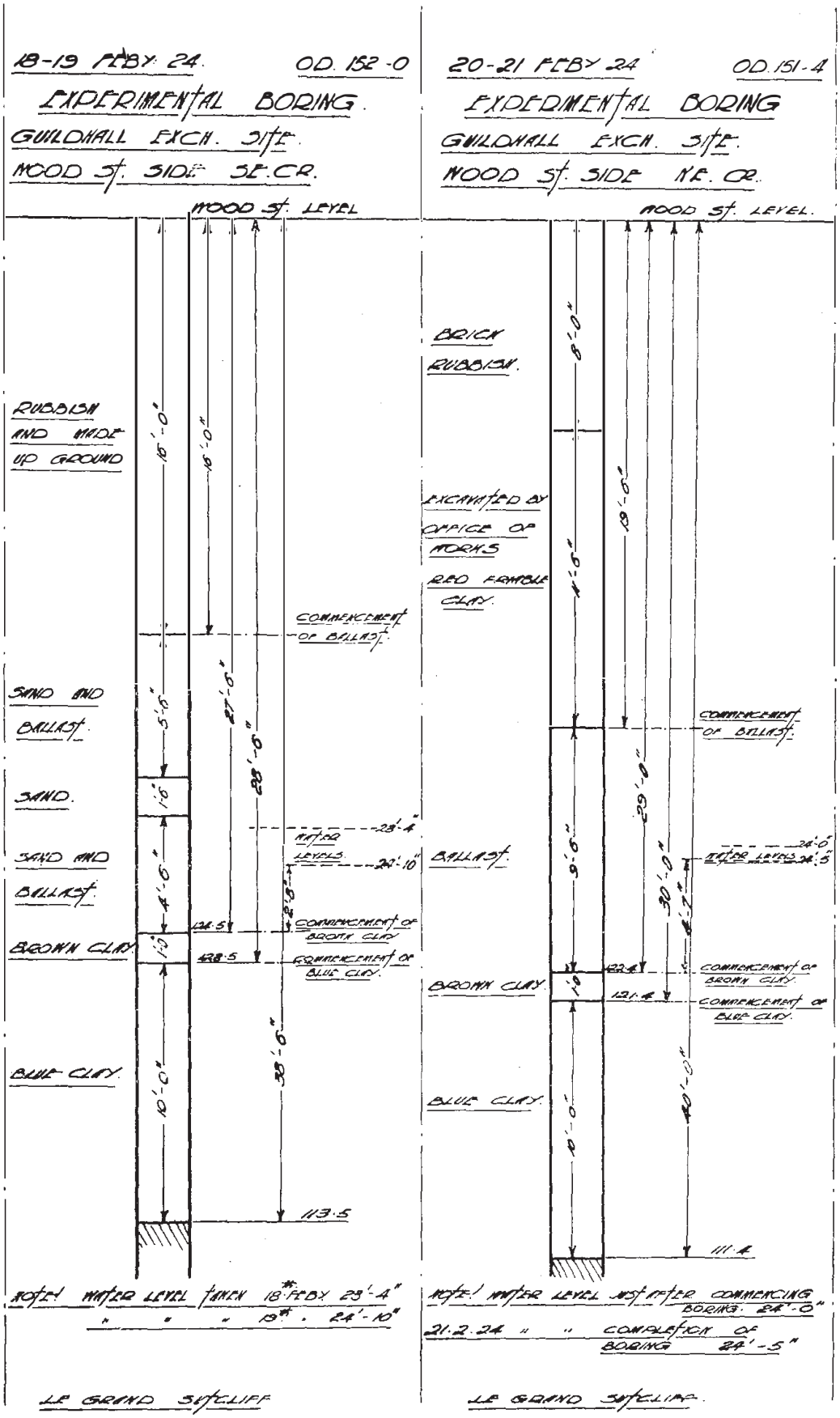


FIG. 5.—RESULTS OF BORINGS AND INDICATING WATER LEVELS.

follow a course nearly vertically below the foundations of important buildings, could only be done if the usual engineering practice in such circumstances were followed. Long tunnels in city areas are never undertaken except under the supervision of a Consulting Engineer, and the Department was fortunate in being able to obtain the services of Mr. Harley H. Dalrymple Hay, M.I.C.E., who had already been engaged in that capacity on the Post Office Tube Railway (London).

In order that the Consulting Engineer should know the condition of soil which would be met with, the Department placed contracts with two well known firms of well sinkers to make borings through the subsoil to a depth of at least ten feet into the

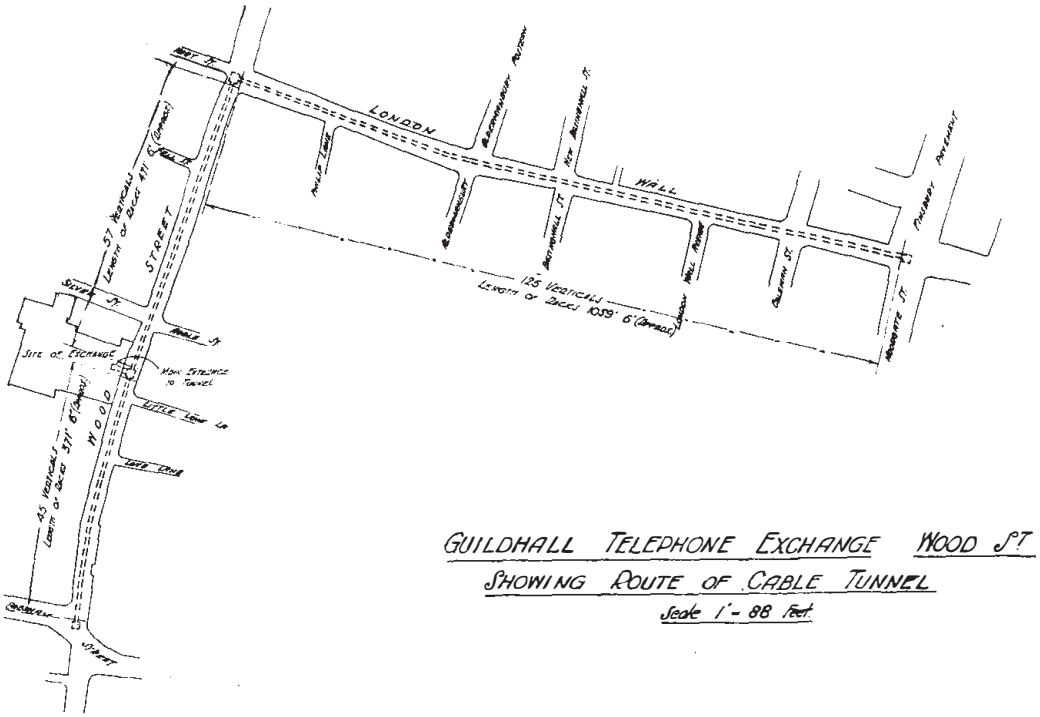


FIG. 6.

London clay. This work was carried out by Messrs. Le Grand Sutcliffe & Gell, of London, and Messrs. C. Isler & Co., of London and Birmingham.

From what has already been said about the traffic conditions and underground services it will be clear that boring to ascertain soil conditions could only be done during week-ends, and after a small excavation had been made to a greater depth than that of the supply services. It will be seen from the drawing that these openings were made at regular intervals along the route to a depth of rather more than 40 ft. From the information thus obtained the line of the tunnel was fixed. The conditions were then ripe for the preparation of the specification by the Consulting Engineer who,

of course, looked to the Department to supply all information as to its requirements.

It would overburden this short account if full details were given of the dimensions of all parts of the tube. The following particulars may, however, be not without interest. Those who desire fuller details will be able to get them from the illustrations. The main section has an internal diameter of six feet, and extends from the junction of Wood Street and Gresham Street to London Wall and thence to Moorgate, a total distance of 654 yards.

Shafts 4′ 5″ in diameter giving access to the tunnel have been provided from the floors of carriageway manholes already in use

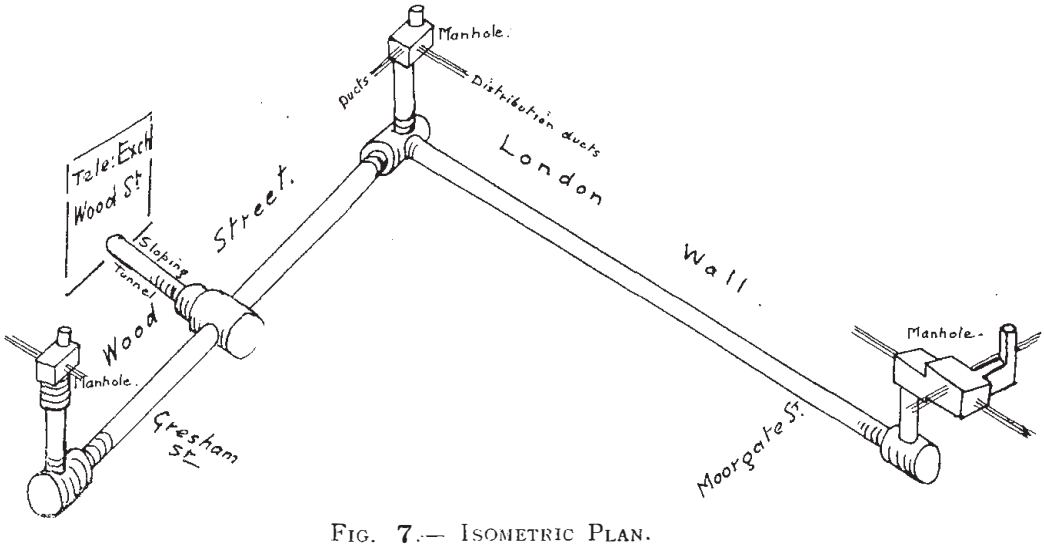


FIG. 7.— ISOMETRIC PLAN.

on the distribution ducts at Gresham Street, at the junction of Wood Street and London Wall, and at Moorgate. The depth from the street levels of these shafts is about 42 ft. to the centre of the 6 ft. tunnel.

The connection to the Exchange basement is made through a sloping subway 8 ft. in diameter and 48 feet long. This subway is constructed at an angle of 30° and concrete steps have been built in it so that access is readily obtained.

The whole of the excavation work except that involved in the construction of the sloping subway was done in free air. For the sloping subway, which passed through the water-bearing ground, it was necessary to provide an air-lock and work in compressed air to keep back the water.

It has already been mentioned that the three shafts enter the floors of existing manholes. This simple statement conveys no idea of the difficulties which the Department's staff met with before this could be arranged. It was necessary to enlarge each of the manholes to provide the space required by the large open-

ings from the shafts. Sewers and large mains had to be diverted to allow of a straight drop down the shaft. The City authorities allowed this work to be done at their convenience and did not press the conditions they had laid down because we were working on existing plant. At Moorgate the traffic conditions at the time were so heavy that the work was held up for more than three months before it could proceed. It will be seen from the route plan that these manholes are in each case at street junctions where

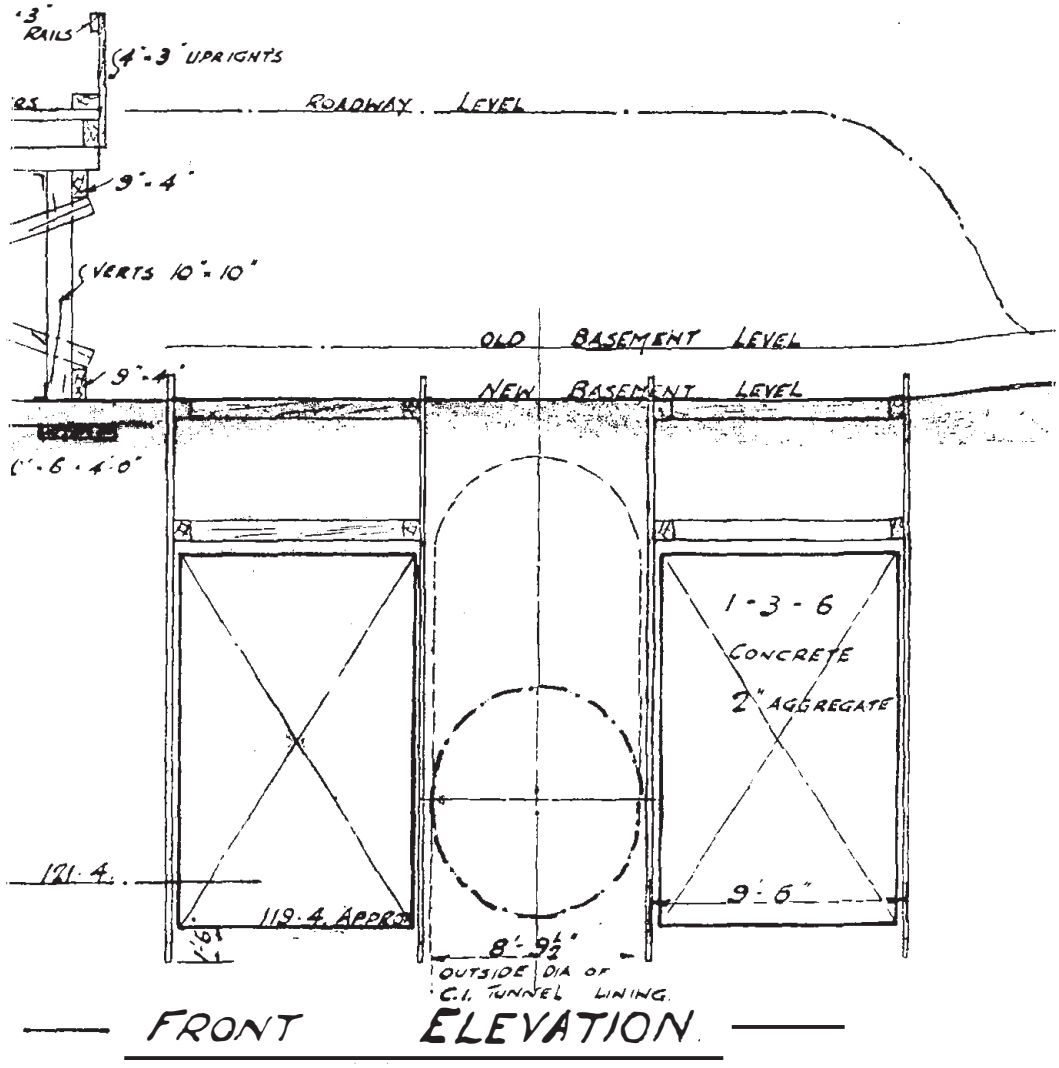


FIG. 8.—SHOWING POSITION OF TUNNEL.

there is more carriageway space than is to be found in either Wood Street or London Wall.

The sloping subway which serves the building made it necessary for the Office of Works to take precautions to ensure that their foundations would not be weakened. The position of the subway was so arranged that it came between two of the main columns of the building. These columns had in consequence to

be put at a greater depth than any others on the site, and this put their bases into waterlogged ground. It was, therefore, decided to build the columns inside a framework of steel interlocking piles.

The piles used were 24′ 6″ long and were driven in 20 ft. and reached a depth of approximately 40 ft. The site enclosed by them was 20 ft. by 9 ft. 6 in. The only water that had to be dealt with was that trapped in the space enclosed by the piles. After the ground had been excavated inside the piles the whole space was filled with a good quality concrete.

The clearance between the piles and the subway is only about four inches, and the whole space around and above the subway to the top of the piling will be filled with concrete.

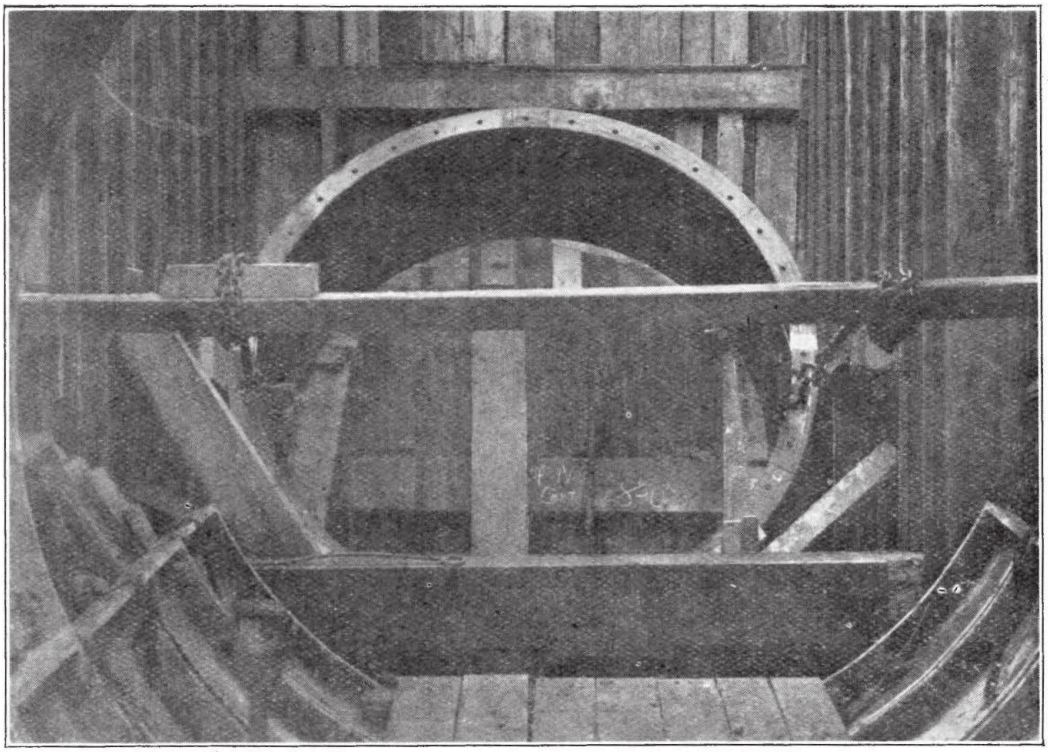


FIG. 9.—FIRST RINGS IN POSITION.

The water difficulty which caused the piling to be done was, of course, present during the making of the subway, as previously stated, and made it necessary to carry out this portion of the work under compressed air. The use of compressed air makes work through water-bearing ground much simpler and quicker than it would be without air. Every foot in height of water exerts a pressure of .434 lbs. per square inch and therefore, if air, which is under a pressure above normal corresponding to the head of water acting upon the tunnel, is introduced, the flow of water is held back from the excavation and the work is carried out in practically

the same way as in dry ground. The air pressure introduced is sufficient to hold back the water at the bottom of the tunnel. In the subway the air pressure was about 5 lbs. per square inch.

The air pressure is made available by means of an air lock.

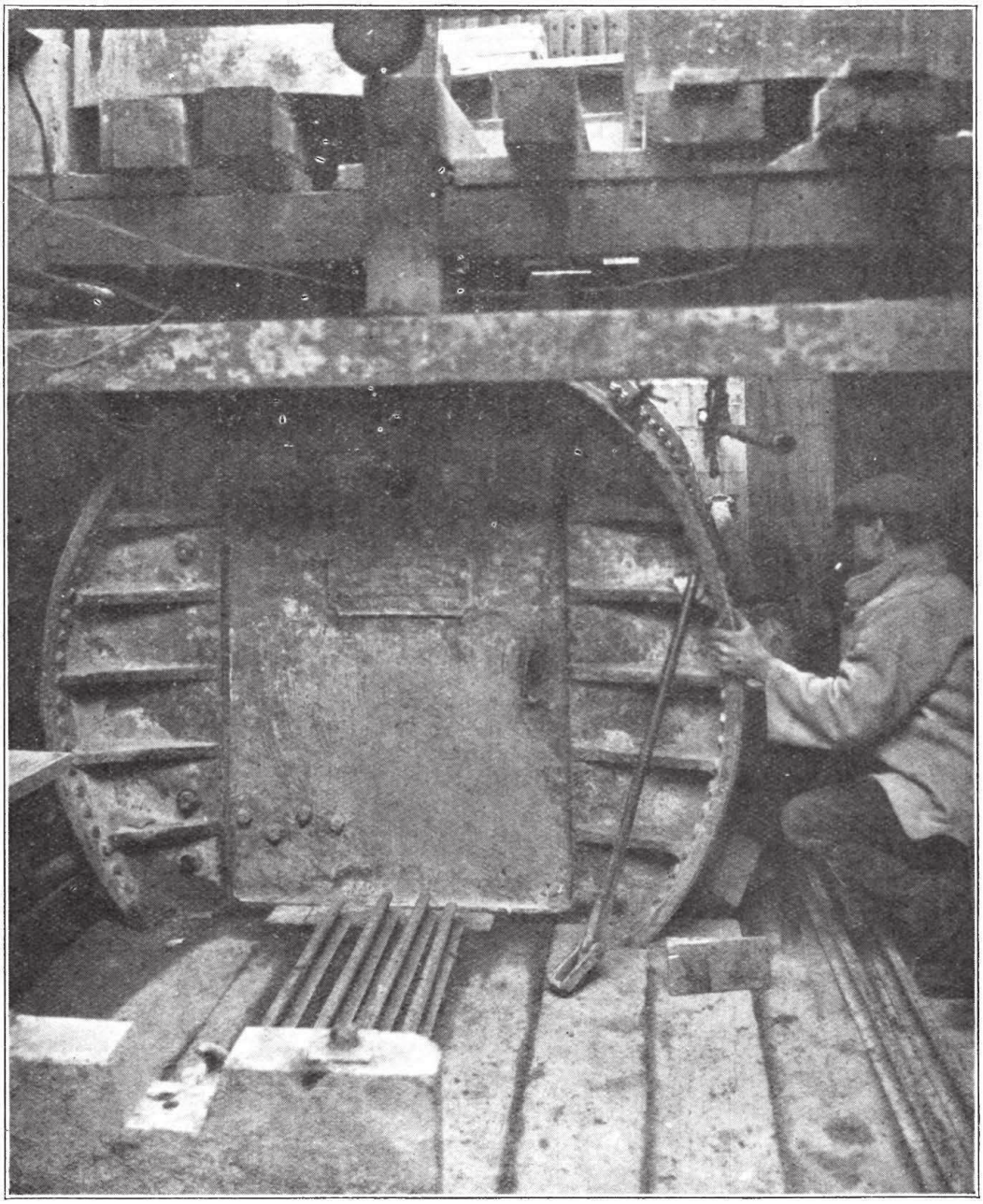


FIG. 10.—AIR LOCK ENTRANCE.

Its appearance will be better understood from the photograph than by a lengthy description. Access to the air lock is through the door shown. This door is forced to, and is quite air-tight when the pressure is on.

The sensation of being under air pressure above the normal is not altogether pleasant. When the pressure is first applied it sets up a throbbing in the head. The best way to counteract this increase of pressure is to pinch the nose tightly and force air into the nostrils and air passages, so as to counteract the increased external pressure on the diaphragms of the ears. The normal speaking voice is of little use; it is necessary to shout in order to be heard.

FIG. 11.—LOOKING UP SLOPING TUNNEL.

It has already been stated that the main tunnel is 6 ft. in diameter. The cables to be carried in it will reach the exchange from two directions and this made it necessary to increase the size of the exchange subway to 8 ft. diameter. The junction of the subway with the main tunnel is made by increasing the diameter of the subway section by steps up to 14 ft., and the

largest section forms suitable space for manipulating the cables. This is shown in the photograph taken from the foot of the subway.

The excavation of the tunnel proceeded without a hitch from the beginning to the end of the work. Owing to the small diameter of the tunnel only two diggers could work on the face at

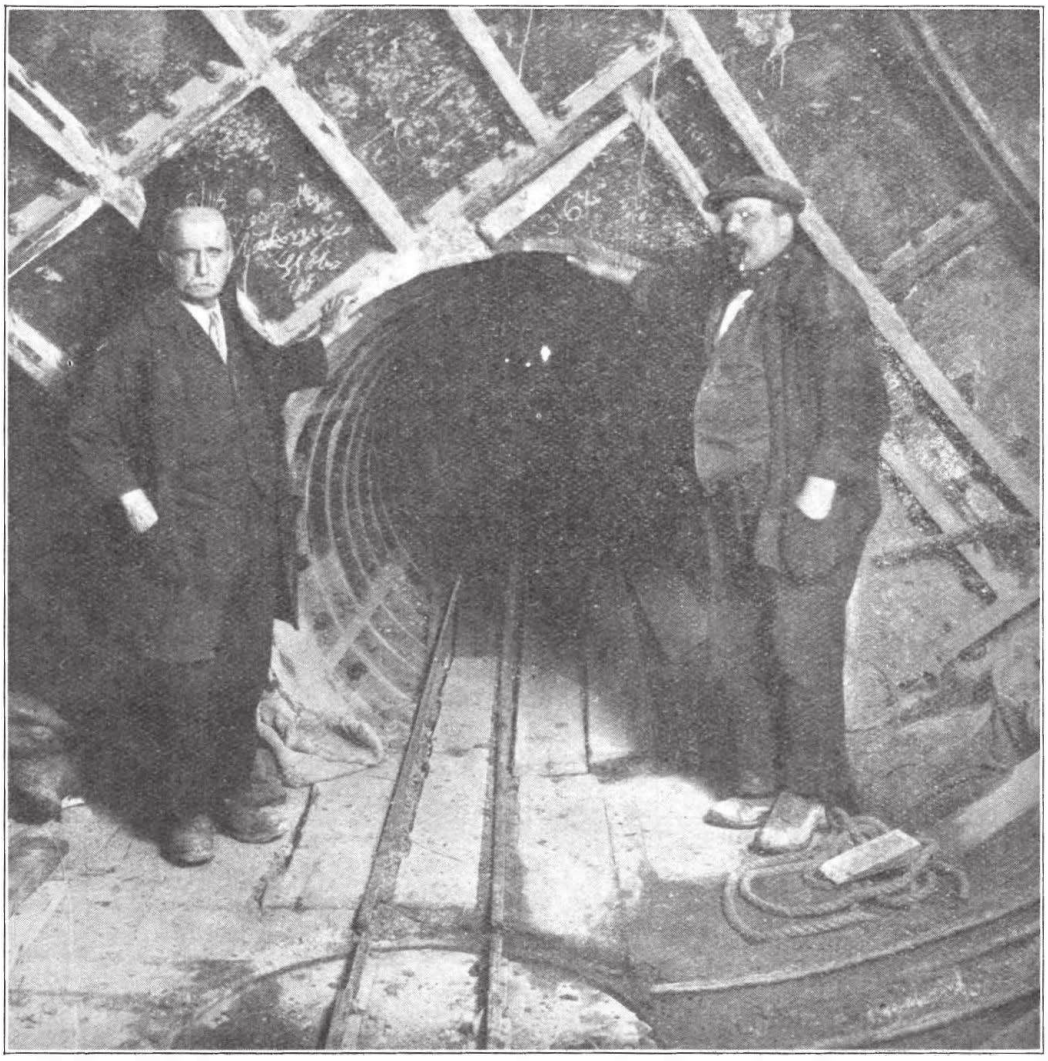


FIG. 12.—VIEW FROM FOOT OF SUBWAY.
(On the left Mr. Steve Morgan, P.O. Inspector of Works.)

a time. As the clay was removed it was filled into trucks and hauled by electric motor to the exit. At this point it was lifted by a crane fixed on an overhead staging, and dropped into carts underneath. Six complete cast iron sections were put in each day, the men working double shifts of eight hours.

Each section measured 1′ 8″ long, and was inserted immediately the excavation to take it had been made. There is a hole

1″ in diameter in each casting through which a Portland cement grouting was forced at a pressure of 60 lbs. per square inch.

The blue clay is an easily worked substance. The tunnel is at least 10 feet below the surface of the clay, which at this depth was found to be dry and tough. Occasionally the excavators came across a substance known as clay stone. This is very much harder than the clay usually met with, but is believed to consist only of clay which has been subjected to exceptional pressure.

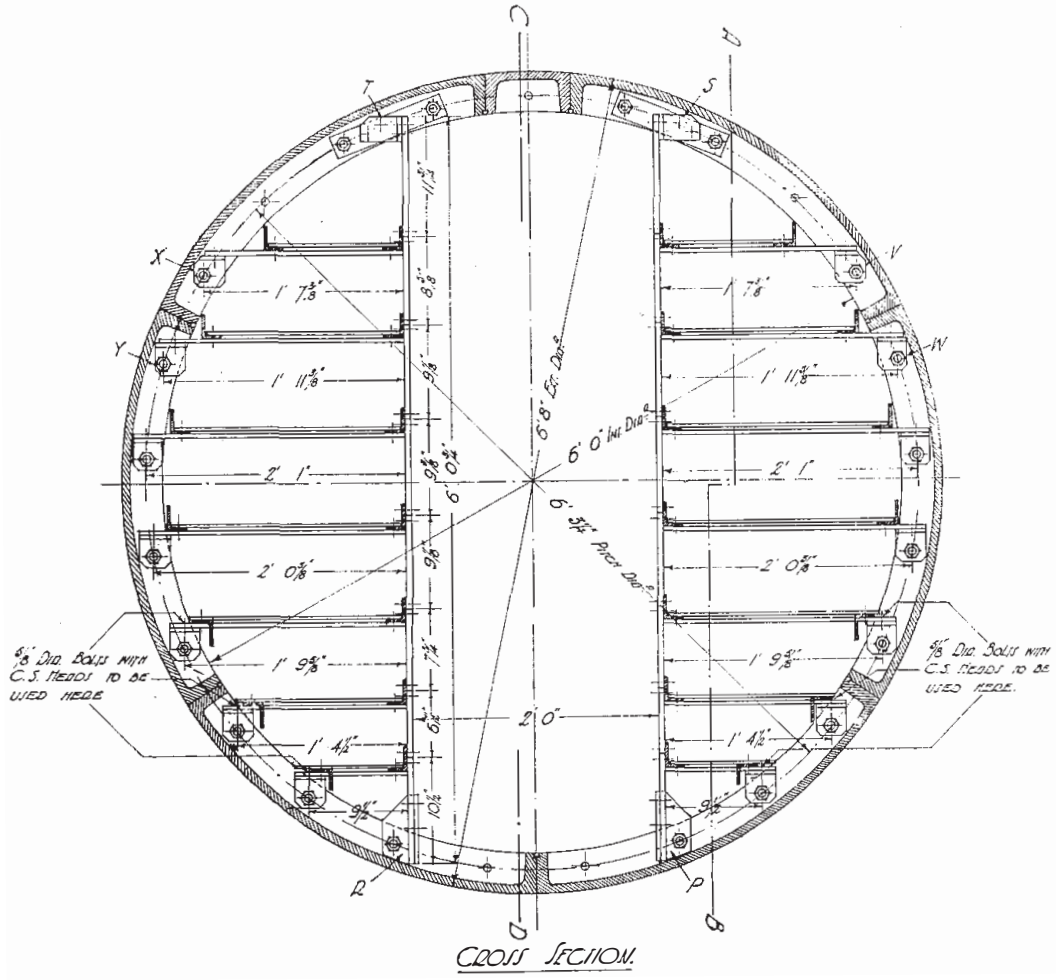


Fig. 13.—Section showing Cable Bearers.

The contractors were Messrs. Mowlem & Co., who also carried out the Post Office Tube Railway (London).

The tunnel will provide space for about 80 cables on bearers. Should it be found necessary at a later date a considerable increase in this number could be obtained by dispensing with some of the bearers.

The bearers are being supplied under a separate contract, and when completed will have the appearance shown in the diagram.

It will be seen that the verticals are bolted together so that sections can readily be removed in order that the cables can be placed on the racks.

The tunnel will be fitted throughout with electric light. Arrangements are also being made for ventilating fans to be fitted. Electrically heated melting pots for plumber's metal will also be used.

In order to avoid gas accumulations which might leak into the tunnel from ducts led into the surface manholes, 2″ iron pipes will be led from points as high up the walls of these manholes as it is possible to get them, to the surface of the street at the building line.

It remains to be seen how far this form of construction will be necessary in the future. The increasing demand for telephone service in London, and the conditions under the streets due to the presence of other undertaker's plant make the provision of duct work difficult, apart from inconvenience which surface openings cause to traffic, so that it is not improbable that more work of this kind will be required.

I have to thank Mr. O. P. Moller for the assistance he has given me with the illustrations for this article, and also Mr. H. C. Stone for the details which show the congested condition of the subsoil in Wood Street. The drawing which shows the cable bearers in the tunnel was prepared by the London Engineering District.

H.B.

THE POST OFFICE WIRELESS SERVICES.

THE completion of the high-power station at Rugby, with its many novel features largely due to the resource and initiative of Post Office engineers, and its success as a telegraph and telephone transmitting station have received generous notice in the press of the day, and have called attention to the important and increasing wireless services conducted by the Post Office by means of its point-to-point and coast stations. A short account of the stations and the organisation by which these services are operated will be of interest to readers of the Journal.

The point-to-point stations are under the control of the Engineer-in-Chief for all purposes. The coast stations are controlled by the Inspector of Wireless Telegraphy, and his staff of Wireless Overseers and operators perform day-to-day maintenance work in addition to operating, although the major maintenance of these stations is in the hands of the Superintending Engineers of the Districts in which the stations are situated. The Engineering Department took over the point-to-point stations from the Inspector of Wireless Telegraphy on 1st April, 1925. This change was brought about by the rapid increase in the size, power and complexity of the stations intended for long distance working, with the consequent necessity for the employment of trained engineering staff. The general adoption of the land line control method of operating such stations, by which the staff of telegraphists is concentrated at the Central Office in London, also contributed to the change of policy, as the point-to-point stations have in fact become relay stations at which the retention of operating telegraphists is unnecessary. A map showing the location of the Post Office Stations is given on page 59.

The stations transferred to the Engineering Department under the new arrangements are as follows :—

Leafield, with Banbury Receiving Station, collectively known as "Oxford Radio."
Northolt.
Stonehaven.
Devizes.
Radio Relay Station, London.
Caister.

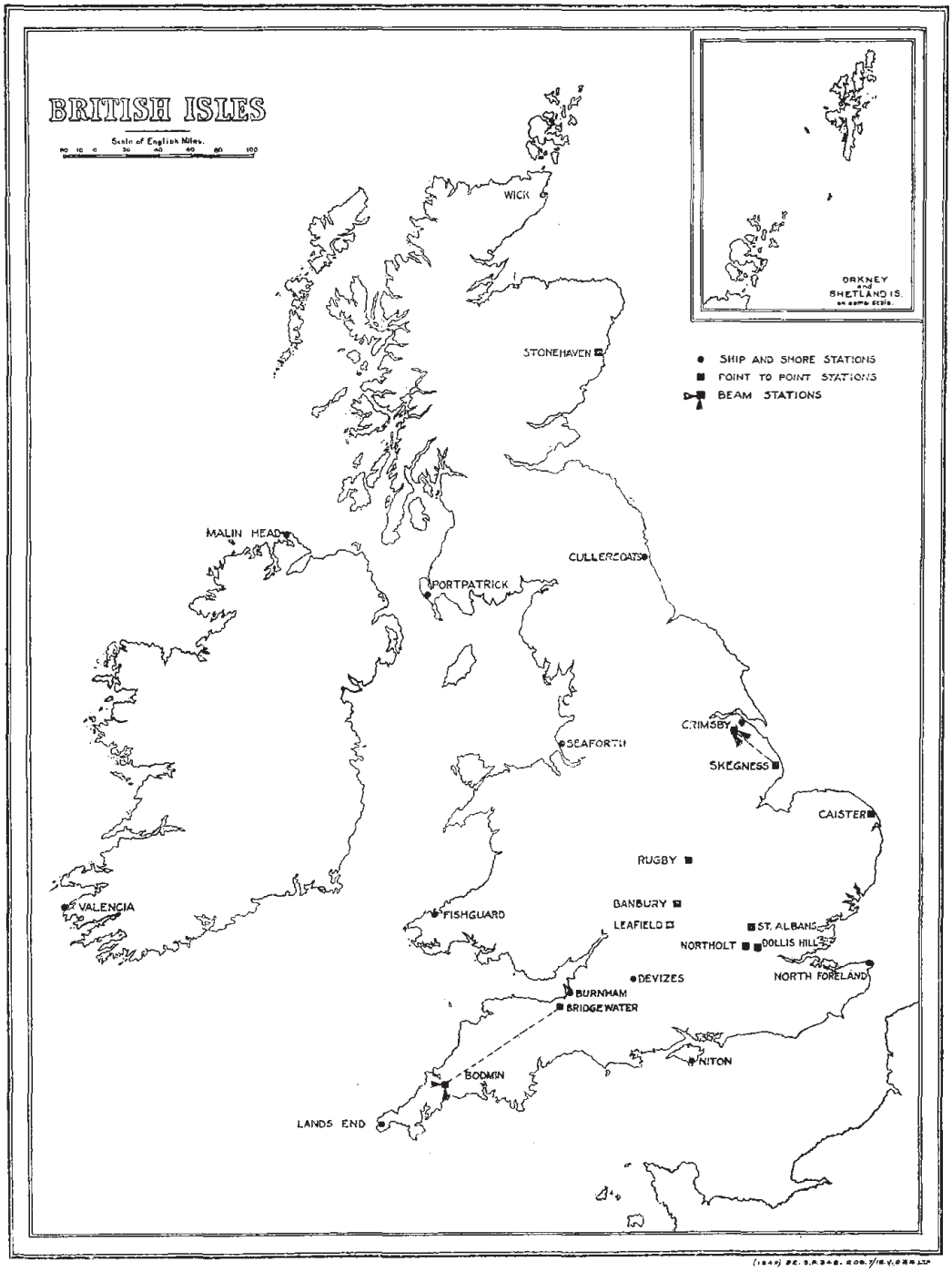


FIG. 1.—LOCATION OF P.O. WIRELESS STATIONS.

Cairo, the sister station of Leafield, remains under the Inspector of Wireless Telegraphy and is manned by his staff, including some engineering officers seconded for service at the station.

Leafield and Banbury ("Oxford Radio") form one group under the charge of an Executive Engineer, with the necessary staff of Shift Officers, arc attendants, turbine drivers, etc. Banbury is still staffed by overseers and operators seconded from the commercial side, who are mainly employed in the reception of inward Cairo traffic. The necessity for retaining Banbury as a receiving station arises from the unsuitability of the Radio Relay Station in London for the reception of long distance and difficult signals, owing to local interference from power plant in the neighbourhood. A new receiving station for all services is in course of construction at St. Albans, and it is anticipated that this station will be able to relay Cairo's signals to the Central Radio Office, as is already done in the case of Continental Services.

Leafield and its complementary station, Cairo, were the first and only stations of the Imperial Wireless "Chain" to be completed. The necessity for the chain disappeared as the range of the high-power stations, of which Rugby is the latest example, increased, until it became world wide. They were originally designed in 1913 as 300 K.W. spark installations, with crystal reception, and it is interesting to speculate upon the probable measure of success which they would have attained under these conditions. The installations were commenced but the outbreak of war interrupted operations, and the subsequent development of other methods rendered it necessary to reconsider the design of the stations. In 1919 it was decided to proceed with the installation of 250 K.W. Elwell-Poulson Arc transmitters, and Leafield and Cairo were erected by the Post Office Engineering Department and completed in 1921 and 1922 respectively.

Leafield is situated on a plateau 600 ft. above sea level, approximately 20 miles N.W. of Oxford. No power supply being available, a complete steam generating plant was installed. Two Babcock & Willcox water tube boilers, each capable of evaporating 10,000 lbs. per hour and fitted with superheaters, provide the steam required. The prime movers consist of two 250 kilowatt Allens de Laval type steam turbines, each coupled to two 500 volts D.C. generators in series, thus giving the 1000 volt D.C. supply required for the arc generators. Two 60 K.W. turbo generators, of the same type, supply the power necessary for auxiliary purposes at a pressure of 220 volts D.C.

The water supply for the Station is obtained from a well situated in the valley some two miles distant, at which a pumping

station has been erected. A reservoir to contain 50,000 gallons was built at the top of the wireless site, and also a cooling pond, measuring 200 ft. × 200 ft., to hold 1,000,000 gallons of water for the condenser circulating system.

The arc generators are designed for an input of 250 K.W. and are each capable of delivering a current to the aerial of 250 amperes at a frequency of 24.3 kilocycles, corresponding to a wave-length of 12,350 metres. In order to eliminate harmonics and mush, emitted by the arcs, a coupled circuit has recently been installed. The four condensers used in the primary circuit, each of which have a capacity of .025 μ.f., are constructed of aluminium plates supported in steel tanks. The dielectric used is oil.

Typical readings of the coupled arc circuit are given in the following table:—

D.C. Supply to Arc.		Primary Circuit.	Aerial Circuit.	Wave-length.
Volts.	Amps.	Amps.	Amps.	Metres.
660	320	225	230	12,350

The keying is carried out by means of a Creed pneumatic key having eight pairs of contacts, which short-circuit coils coupled to an inductance fitted in the primary circuit, thus causing marking and spacing waves to be emitted, the difference in wave-length between the marking and spacing waves being 40 metres. The keys are capable of a speed of 80 words per minute.

The aerial, which is of the inverted L type, is supported by ten tubular steel masts, each 305 ft. in height. It is constructed with 7/19 phosphor bronze wire and is approximately 1000 yards long by 200 yards wide.

Leafield is utilised for commercial purposes to Cairo and Prague and for a press service to Halifax, Nova Scotia. The Halifax and Prague traffic is dealt with at about 40 words per minute as a rule, and the Cairo work usually at from 18 to 25 words per minute.

Until recently the British Official Press, the Long Distance Ships commercial service and the Marconi Company's and Radio Communication Company's press services to ships were transmitted by Leafield, but the desirability of a world wide range for these items has led to their being transferred to Rugby.

The day range of Leafield and Cairo is 2,500 miles, but the night range is very much greater, and during tests made last year Leafield was received at strength 8 (strong signals) in the China Seas.

Northolt Radio Station is situated 11 miles W.N.W. of London and was put into commission in August, 1921, using two 25 K.W. Elwell Poulsen Arc transmitters. A 30 K.W. Valve transmitter was installed in 1925 and the two transmitters are

now in simultaneous use daily. The power supply is obtained from the Uxbridge Power Supply Company at 6,000 volts, 3-phase, 50 cycles per second, and is transformed down to 415 volts for use on the Station. Motor generators giving 650 volts and 110 volts D.C. are provided for the main and auxiliary power supplies.

The valve transmitting set is equipped with a valve rectifying unit consisting of 6 2½ K.W. Silica Valves. These are fed from a 3-phase transformer, three-phase full wave rectification being employed. This rectified supply is fed to the oscillating unit, which consists of 3 water-cooled 10 K.W. metal valves.

To ensure constant frequency and wave-length a system was developed and first used practically at Northolt in which a valve-sustained tuning fork working at audible frequency provides the control for the main oscillators. A harmonic of this frequency is selected for amplification.

Keying is carried out by the simultaneous interruption of the grid circuits in the second stage of the tuning fork, and also in the grid circuits of intermediate valve and oscillating valves. The key used for breaking the last two connections is a Creed pneumatic, double contact type. The break in the tuning fork stage is effected by means of a small auxiliary key.

Typical readings of the valve set are given below:—

D.C. Input.			Intermediate Circuit Amps.	Aerial. Current.	Frequency.	W.L.
Volts.	Amps.	K.W.				
7,700	3·7	28.5	33	70	43200	6940

The two 25 K.W. arc transmitters are designed for an input of 40 K.W., and are connected to the aerial through a coupled circuit in order to eliminate undesirable emissions.

Typical readings for the arc sets are as follows:—

D.C. Supply to Arc.		Intermediate Circuit.	Aerial Circuit.	Frequency.	Wave-length.
Volts.	Amps.	Amps.	Amps.		
460	63	46	38	72070	4160

Keying is carried out by means of a single contact Creed pneumatic key which short-circuits a small portion of the inductance in the primary circuit, thus emitting marking and spacing waves, the difference between these two wave-lengths being 80 metres.

The aerials are supported from three wooden lattice masts, each 446 ft. high, arranged in the form of an equilateral triangle, and one 300 ft. tubular steel mast.

The Northolt Valve transmitter is used mainly for European broadcast press services, but, in addition, it maintains commercial

services with Buda Pest and Belgrade. The arc transmitter is allocated wholly to Italian traffic, working in conjunction with Milan. The press, which is received at a large number of stations on the Continent, is forwarded at hand speed but the commercial work is dealt with at speeds up to 50 words per minute.

Stonehaven was originally designed and completed in 1916 as a two transmitter station, with 30 K.W. and 5 K.W. spark installations, to serve the dual purpose of coast working with ships and for emergency communication with Aberdeen in the event of a total breakdown of the land lines connecting that city with the South. The development of continuous wave transmission led to the addition of two 25 K.W. arc sets and later to the conversion of the 30 K.W. spark set into a valve transmitting installation of similar power. The latter task was undertaken by the Post Office Engineering Department after enquiries had shown that satisfactory tenders from outside firms were not forthcoming for a valve installation of this size. A large amount of pioneer work was done in connection with this alteration, with a result which more than fulfilled expectations, as the aerial power was doubled as compared with the arc with a smaller expenditure of electrical energy.

A public supply not being available, generating plant consisting of two 75 B.H.P. Gardner oil engines direct-coupled to 40 K.W. 220 volt, Crompton generators is installed, together with a storage battery of 120 cells of 1070 A.H. capacity. The high tension D.C. supply is derived from Crompton Motor-Alternators, the output on the generator side being 30 K.W. at 1000 volts, 350 cycles. This supply is transformed, rectified and smoothed for delivery to the transmitting valves at 12,000 volts. Rectification is effected by means of two sets of three two-electrode valves, V.T. No. 21, in parallel. The transmitting valves, V.T. No. 19, eight in number, are connected in parallel and are each capable of dissipating 800 watts from the anode. Current for the valve filaments is obtained from 5 K.W. motor-alternators through a step-down transformer, the supply being 16 amps. at 16.5 volts. Separate secondary windings are provided on the transformer for the rectifying and oscillating valves. The wavelength is 4600 metres.

Keying is effected by means of a two-contact Creed pneumatic key, the method of keying being that of breaking the grid leak and transformer primary circuits simultaneously. An air blast is provided to prevent arcing at the contacts.

The main services conducted *via* Stonehaven are those to Warsaw and Hapsal (Esthonia); certain Continental press services are also dealt with. The station is used during breakdowns of

cable and land lines for emergency services between London and Aberdeen and to Berlin and Iceland. Although the Aberdeen requirement was one of the reasons for the selection of Stonehaven as a site it should be noted that this function has seldom been brought into operation.

The continental traffic is handled at speeds up to 60 words per minute and the station is a very efficient one, in spite of the serious drawback of its being controlled by a land line nearly 500 miles in length with three repeaters in circuit, and containing long sections of overground line.

Devizes Relay Station, which is controlled from the Burnham Receiving Station, deals with C.W. ship traffic and has a guaranteed range of 1500 miles. It is situated 4½ miles from Devizes and in the absence of a local power supply is equipped with prime movers. Its equipment consists of two 30 H.P. Robey Engines driving 15 K.W. D.C. generators, which are used for operating the transmitters and charging the 450 A.H. battery.

The transmitting equipment consists of two 6 K.W. valve transmitters working on 2100 and 2400 metres respectively. The transmitters, including their running machines, are remote controlled from Burnham, two transmissions being carried on simultaneously.

The first transmitter was installed in 1920 by the Marconi Company and the second was designed and installed by the Department in 1925. The second transmitter is separately excited by means of the Tuning Fork Control System and contains one novel feature. Owing to the relatively high frequency of transmission a double multiplication of frequency is made in the Tuning Fork Unit. The wave generated at the fork frequency (2000 cycles) is distorted to enlarge the harmonics and the 9th harmonic is picked out, filtered and amplified. This 18,000 cycle wave is then distorted and, by selecting and amplifying the 7th or 8th harmonic, frequencies of 126,000 and 144,000 cycles are obtainable, corresponding to wave-lengths of 2380 and 2080 metres respectively.

The aerial systems are suspended from three 300 ft. masts arranged in a straight line and under working conditions currents up to 15 amperes are obtained on each set.

Caister is a 1½ K.W. Valve Station, which is retained for emergency communication with Holland during cable breakdowns.

Rugby and the short wave Beam Stations now in course of erection will be dealt with in future articles. The Beam Station at Bodmin, Cornwall, with its receiving station at Bridgwater, Somerset, is intended for communication with South Africa and

Canada. A second group of stations, Grimsby and Skegness (receiving), are to be utilised for working to India and Australia. Similar stations are being erected in the Dominions named. The guaranteed periods of effective transmission per day by these stations, of comparatively low power, is Canada 18 hours, South Africa 11 hours, India 12 hours and Australia 7 hours.

The Coast Stations were taken over from the Marconi Co. and Lloyds Corporation in 1909: the stations taken over were:—Caister, North Foreland, Niton, Lizard, Seaforth, Holyhead, Malin Head and Crookhaven. The Cullercoats Station was taken over from the Poulsen Company in 1912. All these stations were remodelled or replaced by other stations, and equipped with rotary disc discharge transmitting plant in the years 1913-14. After the war, stations at Wick, Grimsby and Port Patrick were taken over from the Admiralty. The stations at present comprising the coast stations are:—Wick, Cullercoats, Grimsby, North Foreland, Niton, Lands End, Fishguard, Seaforth, Port Patrick, Malin Head and Valencia: the two Irish stations, Malin Head and Valencia, although still under the control of the British Post Office, are manned and maintained by the Irish Free State on behalf of the British Government. The Coast Stations have been further improved from time to time to bring them into line with the latest practice: in 1920 valve receivers replaced crystal receivers at all stations. The power of the coast stations varies from $1\frac{1}{2}$ to 5 Kilo-watts.

Direction finding equipment has been installed in the Niton and Cullercoats stations for giving bearings to ships. This service is of great utility and facilities are to be extended by making similar provision at other coast stations, either in their present positions, or on fresh sites more favourable to direction finding requirements.

The Lands End station has been equipped with direction finding equipment, but this is used only to assist ordinary reception in the face of jamming: the site is not suitable for a direction finding service to ships.

The near future will see the complete remodelling of the Coast Stations: valve transmitters are to be installed and these will be arranged for tonic train transmission, the equivalent of spark transmission with valve equipment. This provision will minimise interference to other services, inherent to the spark system, and will provide immediately for continuous wave transmission if and when it is adopted generally for ship working. The trend of development is that spark working shall be ultimately eliminated.

Experimental short wave (non directive) $1\frac{1}{2}$ K.W. stations have been erected at Dollis Hill, the Post Office Experimental

Station near London, and at Leafield. During the past nine months, Dollis Hill has dealt with traffic for Cairo and Halifax, Nova Scotia, from late afternoon onwards into the night very efficiently. The Leafield short-wave set has just been completed and also promises well. It is the intention to instal short-wave transmitters at Rugby and Devizes in the near future. These sets will be used in substitution for or in addition to the main transmitters when conditions are favourable for short-wave transmission.

The Central Radio Office and the Radio Relay Station are dealt with in another article in this issue. Both these offices are in the Central Telegraph Office building in London. The whole of the wireless point-to-point traffic is dealt with in these offices, with the exception of inward Cairo traffic as previously mentioned, outward by land line control of the various stations, and inward by reception in the R.R.S. and relaying to the C.R.O.

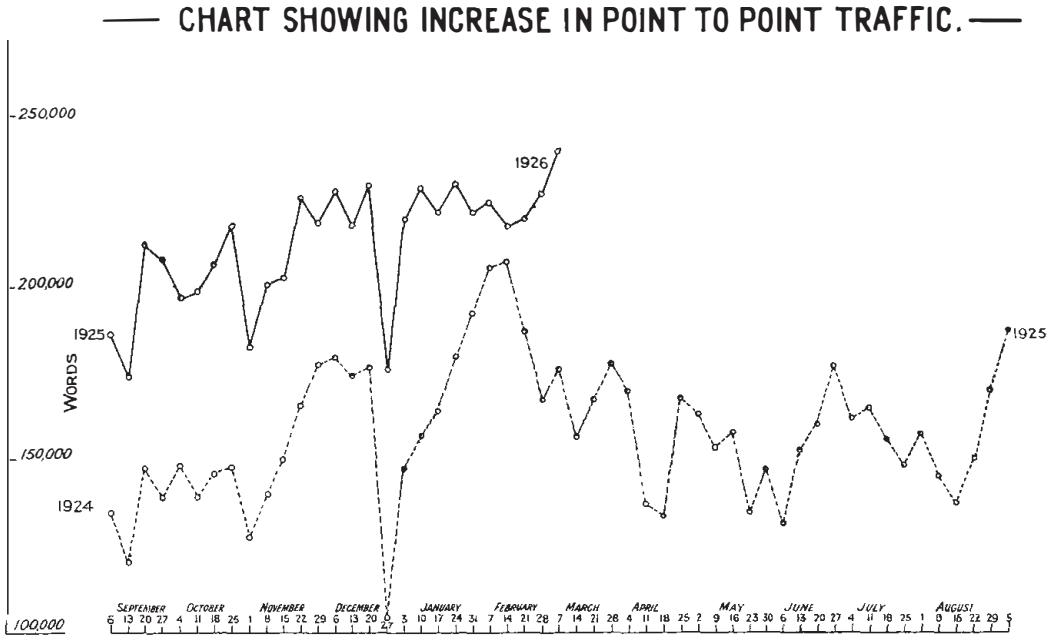


FIG. 2.—GRAPH SHOWING POINT-TO-POINT WIRELESS TRAFFIC.

A graph showing the traffic dealt with by the point-to-point stations since the beginning of September, 1924, and indicating the increase during the past six months, as compared with the corresponding period of the previous 12 months, is appended.

E.H.S.

THE CENTRAL RADIO OFFICE.

By A. IRWIN.

"On the 26th January a duplex wireless service was opened between London and Berlin for a period of three hours daily. . . . . The following shows the traffic passed to and from London on the 25th February and is a fair example of the normal working :—

	Messages.	Words.
Received from Berlin	120	2142
Sent to Berlin	85	1373
Total	205	3515 "

The above is an extract from the April, 1921, issue of this Journal and records what was really the beginning of the point-to-point radio services now controlled from the C.T.O. This service was carried on in a small room on the 4th Floor of G.P.O. West. The Stonehaven radio transmitter controlled by landline from this room was used as the transmitting station on the British side, while Germany utilised its station at Königswursterhausen.

In 1922 an additional service was opened between London and Rome, the Northolt arc transmitter being used for this purpose and controlled from the same room. This room was now being used to its fullest capacity and it became apparent that to develop these services and also to allow for future extensions additional accommodation would have to be provided.

In September, 1922, therefore, these two services were transferred to a larger room which had been built on the roof of the same building. Here better accommodation was available for the existing services and provision made for additional apparatus. Improved leading-in facilities for the increasing number of aerials required was also provided.

During the whole of this period the radio services had to be carried on under two very serious handicaps. In the first place the isolating of these services from cable services dealing with similar traffic, gave rise to difficulty in keeping both services supplied with traffic and, at the same time, equalising the delay.

Secondly, and from the technical side more important, the receiving conditions leave very much to be desired. Owing to the proximity of the aerials and the radio receiving apparatus to the C.T.O. and other sources of electrical disturbance common to large towns, comparatively strong signals only can be received and high speed recording cannot be undertaken to the same extent as would be possible under more ideal conditions of reception.

In addition, owing to the location of the receiving station in a crowded area, no advantage can be taken of any system of directional reception, which experience has shown to be of considerable assistance in the elimination of unwanted and disturbing signals.

The Post Office, therefore, decided that the reception of radio signals should be transferred to a position free from the disturbing factors mentioned above and a Radio Relay Station is now in course of erection near St. Albans, Hertfordshire. As the name implies, this station will be used only for the reception and relaying of the radio signals into the C.T.O., all operating being performed at the latter office.

In order to gain experience under relaying conditions, both from the technical and operating points of view, and also to provide space in the radio room on the roof for additional receivers, it was decided to proceed with the installation of a Central Radio Office in the C.T.O. itself, in close proximity to the Cable Room where similar traffic is dealt with.

The Central Radio Office was opened in February, 1925, and it is the main object of this article to describe in detail the arrangement of this room.

Since the opening of the C.R.O. all table space in the radio room on the roof, previously occupied by landline control apparatus used in connection with the transmitting stations, has been fitted with additional radio receivers. This room has now become *pro tem* the Radio Relay Station, which in the course of a few months will be transferred to St. Albans. This station contains ten receiving sets of various ranges and capable of reception on any wave-length between 20 and 20,000 metres.

The Central Radio Office is situated on the second floor of G.P.O. West, and occupies a floor space of approximately 1400 sq. feet. In order to minimise to the fullest extent the noises in this room, it has been completely screened from other portions of the telegraph gallery. For similar reasons all noisy apparatus, such as Gell perforators and Creed type-printing machines, are fitted outside this room.

Transmitter Control Sets.

As previously mentioned all operating, both as regards transmission and reception, is carried out in the C.R.O. In connection with the former, six control sets have been provided. These are ordinary D.C. Duplex sets which, in conjunction with the necessary landlines, directly control the radio transmitters situated in various parts of the country. Each set is fitted with a Wheatstone transmitter.

It may here be explained that transmission is invariably carried out by Wheatstone transmitter, irrespective of the speed required. In this connection, the type of transmitter ordinarily used for high speed working on landline circuits, has been found unsuitable for radio working owing to its variation of speed when running on the lower limits.

A type of motor-driven transmitter, specially adapted for speeds between 15 and 150 w.p.m., is now being tried and promises to be free from the disability possessed by the standard type of transmitter.

FIG. 1.—CENTRAL RADIO OFFICE, G.P.O. WEST.

CHECK SETS.

A small receiving aerial erected on the roof of the building is connected to three receiving sets fitted on the back table in the C.R.O. These sets are capable of being tuned to the various transmitting stations in use and supply loud speaker signals at the control positions. A complete check on transmission, both as regards the landline and the radio transmitting apparatus, is therefore provided. (See Fig. 4).

TELEPHONE RECEIVING POINTS.

There are 17 positions situated in various parts of the room to which aural signals, at hand speed, relayed from the R.R.S., can

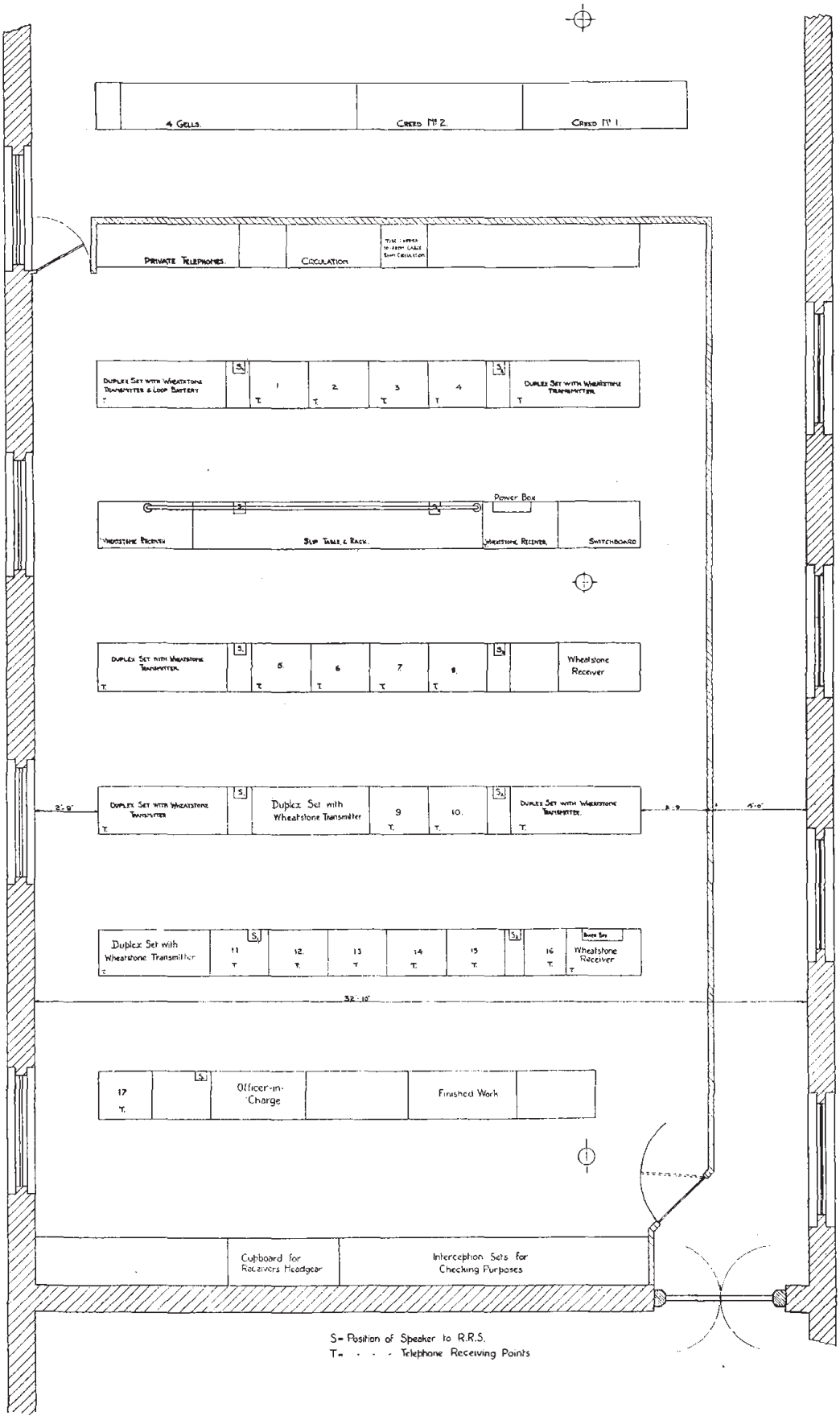


FIG. 2.—LAY-OUT, C.R.O.

be led. These positions are fitted with three jacks joined in parallel, thus allowing for three pairs of headgear receivers being connected to the same line.

Where traffic is heavy but strength of signal or atmospheric conditions will not permit high speed reception, transmission is often carried on at fast hand speed and without the usual pause between messages. In these circumstances two operators are employed, each operator receiving alternately. Under such adverse conditions the transmitter is thereby used to the best advantage.

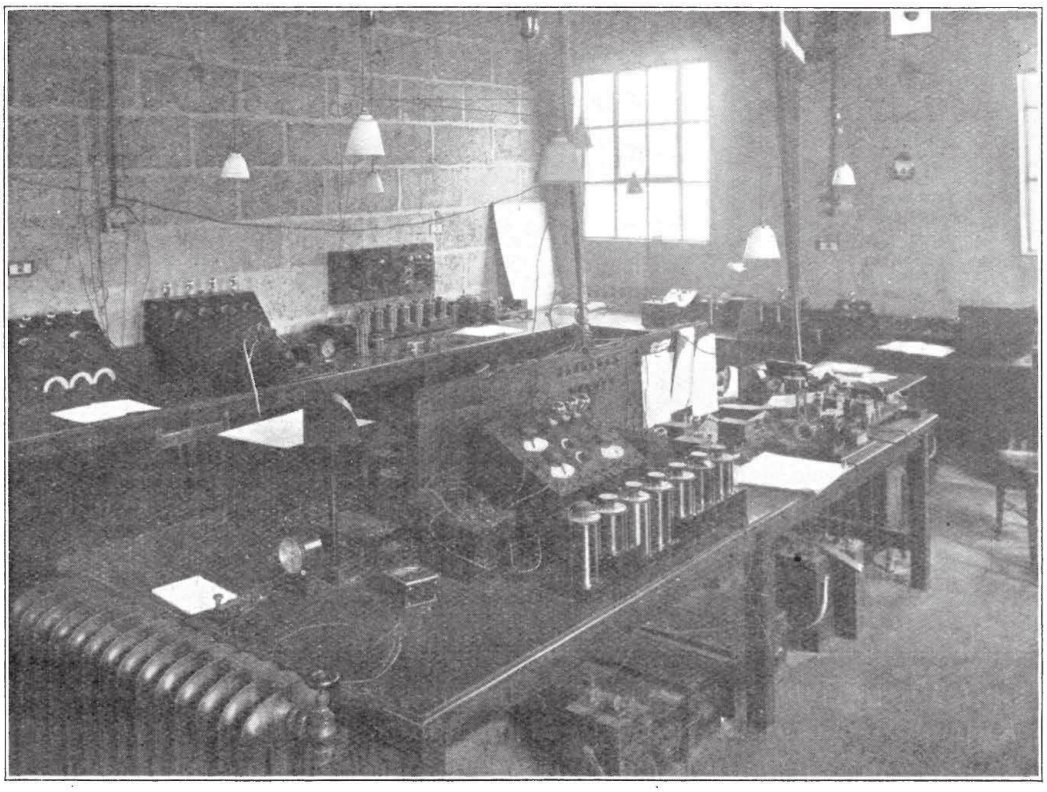


FIG. 3.—RADIO RELAY STATION, G.P.O. WEST.

The third receiver connection enables the Officer-in-Charge to examine the signals being received and thus deal with any complaints which may arise.

WHEATSTONE RECEIVING POINTS.

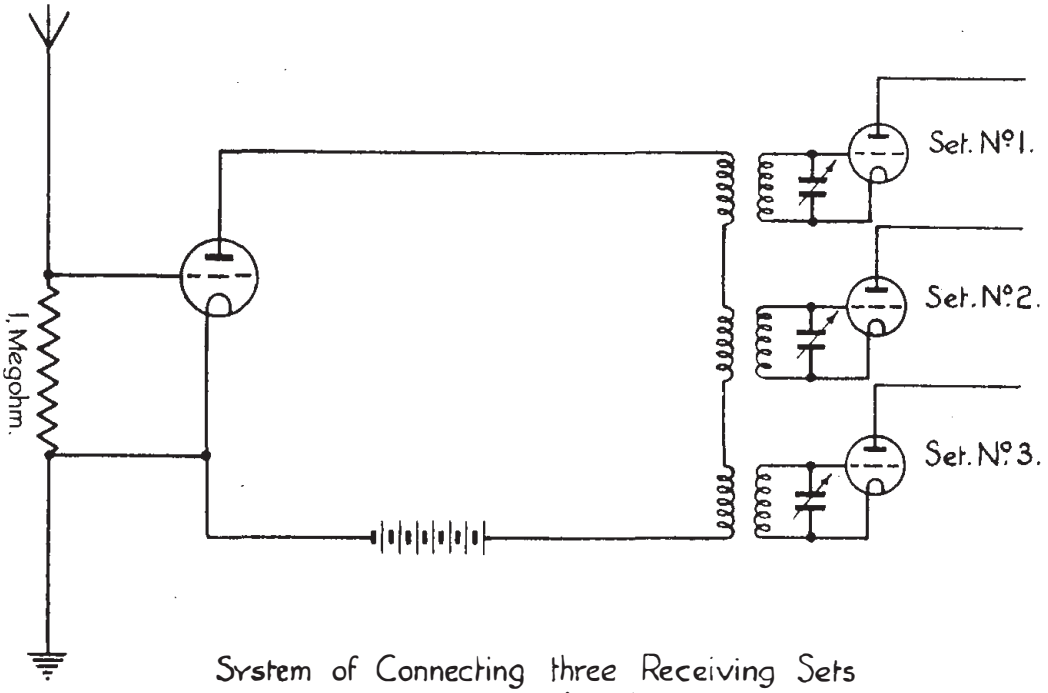
In spite of the adverse conditions before mentioned, improvements in the radio receiving and recording apparatus designed by the Post Office has enabled a considerable amount of high speed reception to be carried out. The actual recording of radio signals is done in the R.R.S. and relayed in the ordinary way over lines to the C.R.O.

Four Wheatstone receiving sets adapted for Creed working are provided in the C.R.O. The aural signals being recorded are also led to this position. The operator can thus receive aurally any remark concerning the work which may occasionally be transmitted by hand.

This combination also permits an operator who may be receiving aural signals to refer to the slip, should confirmation of the whole or part of a message be desired.

Local Speaker Sets.

Two local speaker (Sounder) sets are provided between the R.R.S. and the C.R.O. In the case of the latter room these sets are duplicated on each desk, thus providing ready access to a



System of Connecting three Receiving Sets to one Aerial.

Fig. 4.

speaker for an operator in any part of the room. To avoid unnecessary noise from this source, each set is fitted with a switch for cutting such set out of circuit when not required.

With the exception of the speaker sets, which are directly connected to their relative sets in the R.R.S., connections from all the above described sets are led to the switchboard in the room. To this switchboard are also connected all lines from the R.R.S., junctions to TS Provincial Test for extending to the C.R.O. the necessary land lines from transmitting stations, and also means for connecting the relays of the Wheatstone Receiver sets to the Creed printing apparatus outside the room.

It can be seen therefore that this arrangement provides for complete interchangeability, and allows for the grouping of services where, as in the " fork " system, one transmitting point controls several reception services.

Fig. **5** is a skeleton diagram showing the arrangement adopted for the relaying of the received signals from the R.R.S. to the C.R.O. Ten pairs of wires are led from the R.R.S. to the testing point in the basement of the G.P.O. West. They are led into this position instead of being taken direct to the C.R.O. in consideration of the temporary nature of the present R.R.S. arrangement; this arrangement allowing for the permanent connections between St. Albans and the C.R.O. being made with the minimum disturbance to the services.

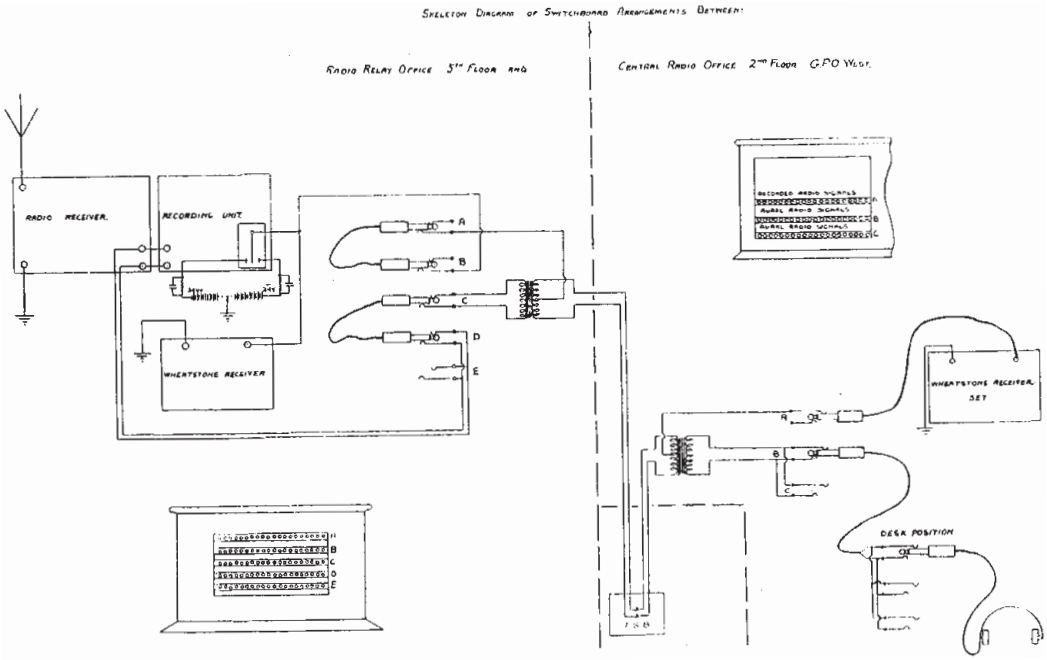


Fig. **5.**

From the testing point in the basement twenty pairs of wires are taken to the switchboard in the C.R.O. Ten of these pairs are joined to the ten pairs coming from the R.R.S. The remaining ten pairs are at present spare and can therefore be utilised during the transfer of the services to St. Albans without in any way interfering with the connections to the present Relay Station.

When the lay-out of the C.R.O. was considered it was anticipated that adequate space had been provided to meet requirements for some time to come, but so rapid has been the development in this direction that with the opening of the Beam Stations now being erected for communicating with the Dominions a further considerable encroachment into the adjoining gallery of the C.T.O. will be necessary.

TRANSATLANTIC TELEPHONY.

By Major A. G. Lee, M.C., B.Sc., M.I.E.E.

It is more than a coincidence that the jubilee of Graham Bell's invention of the Telephone has been celebrated by the achievement of two-way conversation across the Atlantic.

This historic event took place from the Rugby Wireless Sation at 4.0 a.m. on February 7th, 1926. The line from the receiving station at Wroughton, near Swindon, had been extended to Rugby so that the Engineers who were concerned with the experiment could talk from that point. Conversation was opened promptly at the prearranged time and proceeded without interruption till late in the evening.

The next step was to consolidate the work which had been done; lines were tested and frequency characteristics improved and a special hybrid coil balance arranged. An invitation was then sent to representatives of the London Press to witness a demonstration on March 7th, when it was intended, if conditions were favourable, to put each one through to his opposite number in New York, where a similar gathering of journalists had been arranged.

Mr. Shaughnessy filled in the preliminary part of the demonstration with a talk indicating how the radio and line circuits were made up and he showed lantern slides of the salient features of the installations at Rugby and Wroughton.

The first Press representative went into the Telephone Cabinet at 1.30 p.m. and conversed with Miss Mabel Abbott, of the "World," New York. The hour in New York was, of course, 8.30 a.m., and this enterprising lady journalist was the only one of the American reporters present on time, but she carried on a lively conversation with several press representatives on this side until her laggard male confreres arrived.

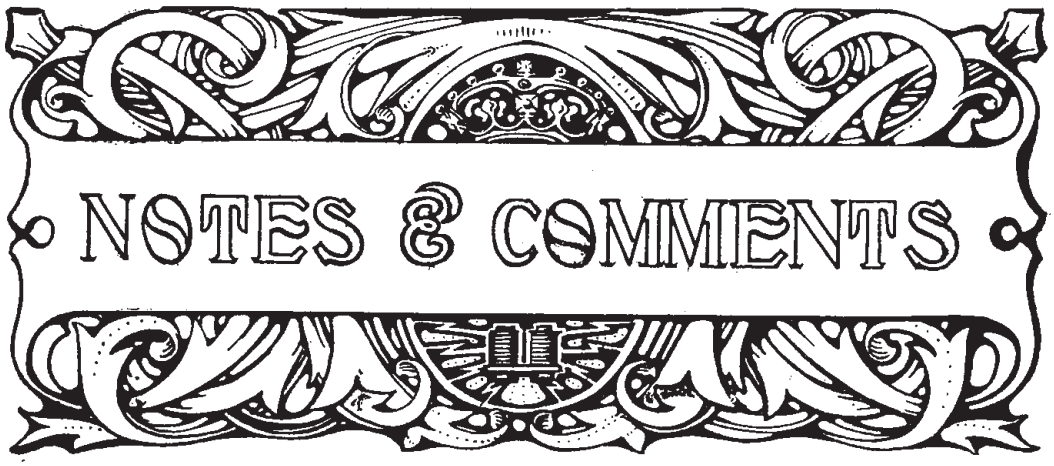
The conversations were continued all the afternoon and were as clear and as easy as those obtained on an ordinary trunk line in this country. Speaking technically, the conversation was a 10 standard mile talk.

The outstanding feature of this demonstration was that it was possible to arrange beforehand for a gathering of people in London to talk to a similar body in New York. The success attending the demonstration came as a complete surprise to the journalists present, who showed a tendency to be somewhat too enthusiastic about the possibilities of an immediate commercial telephone service to America.

Two separate frequencies were used, one of 57 kilocycles for the

transmission from Rocky Point to Wroughton and 52 kilocycles for the transmission from Rugby to Houlton, Maine. The system used is that known as single side band with suppressed carrier, which was first developed by the American Telephone and Telegraph Coy. for use in wired wireless. The modulating equipment at Rugby was manufactured by that Company, while the power amplifier for the telephony was supplied by the Western Electric Coy. The output circuits and aerial and the receiver at Wroughton were constructed by the Post Office.

The American Telephone and Telegraph Coy. are to be congratulated on the successful culmination of a long continued research on the possibilities of long distance wireless telephony, and the Western Electric Coy. and the British Post Office are also fortunate in having been associated with them in this great enterprise.



NOTES AND COMMENTS.

"HISTORY," says Voltaire, "is a fable which men have agreed upon." Not so long ago history was presented in the schools as a sort of vast panorama across which passed in their seasons the magnificent and romantic figures of the great ones of the earth. They were the men that "made history," the men who moulded the destinies of peoples, who founded empires and controlled absolutely the lives of the millions who toiled and fought and died with but scant reward and who were treated as so many pawns to be sacrificed for the opening-up of the game for the higher pieces to manœuvre. We suppose we must agree upon ancient and mediæval history as being something of that nature; that there was actually an age of chivalry extending back to the time of the Round Table and the quest for the Holy Grail; that what really mattered for generations was the fight for supremacy between the House that sported the red rose and the one that favoured the white. It was not until the beginning of last century that public opinion, swelling up from below, began to make itself felt seriously in the affairs of state, although for several generations the yeomen of England had raised their heads—very high in Cromwell's time. Even in military matters the soldiers of the line had gained recognition; at Waterloo, even as at Ypres, the victory was won, not by brilliant leadership but by the men of the county battalions sticking it dourly and not running away.

The invention of the steam engine and the growth of industrialism brought entirely new factors into political operation. The introduction of new processes of manufacture to cheapen production, the discovery of new sources of raw material and fresh markets for the output, and the opening of new means of com-

munication became the historical points most worthy of record. The wars of last century were due rather to financial than, as formerly, to dynastic reasons, in spite of the fact that commerce and finance had become internationalised. However, now that the tumult and shouting of the last great war have died down and the spirit of Locarno is abroad it is the bounden duty of the peoples of Europe to see that business between the nations should be made a means of facilitating peaceful development and not a cause of war. Most people are convinced that commercial intercourse begets better relations, and the more the races get to know each other the more appreciative they become and the less likely they are to start shooting. In this connection the growth of what may be called international telephony is very significant and is bound to have its effects on the future. We believe that Mr. Gill built here even better than he knew. The conferences have been conducted in the best of good feeling and the friendly rivalries over units, methods and systems are all to the good and will tend to bring the best in the associated countries to the advantage of all. The British representatives have been fortunate in their chief; he brought to the gatherings a sense of efficiency and fairness and combined with it a feeling of bonhomie and friendliness which charmed the continental delegates. The Telegraph Conference at Paris contributed a good deal in the same direction, and here again the British delegation owes much to the ability and suavity of Mr. John Lee.

These events form landmarks in the progress towards the closer union of European states, and it is only fair that we should chronicle the Department's share in working towards that end. The telegraph line has long been regarded as a pioneer arm reaching out from civilisation to the dark places of the earth, and the same may be said, with modifications, with regard to the extension of the trans-continental telephone system. One cannot conceive anything but good arising from the extension of communications, but lest our successors in the future meet with difficulties and troubles at present unforeseen let us here produce the following anecdote which carries its own moral. "Once upon a time a telegraph company built an aerial line across the desert separating two trading centres. The surveying staff did their work so well that the route was followed ever afterwards by the caravans. In the fulness of time well-defined tracks became outlined along both sides of the pole route. One day a traveller came along and in his haste he collided with one of the poles. A letter to the 'Times' followed, in which he pointed out the iniquity and crass stupidity of the telegraph administration in running their unsightly poles right down the centre of the road!"

Captain Carter writes to point out that in his article on the Ingersoll Rand Equipment, which appeared in our last issue, the figures shown on page 366 should be numbered across the page (5), (4), (3). Fig. **6** shows the 156H tool in operation, not the 158.

The Relay Automatic Telephone Coy. has completed a P.A.B.X. with a capacity for 6 A and B Feeds and 40 lines for the B.B.C. Station at Broad Street, Birmingham. The Exchange Battery drives the Ringing Machine, which also provides the standard tones, dialling tone, ringing tone, busy back tone and number unobtainable tone. A one-position manual board fitted with 4 exchange and 2 tie lines and 7 cord circuits is installed alongside the auto. racks in the same room.

The contract for the new Fontainebleau exchange, which we mentioned in last issue as having been placed with the Relay Coy., covers an equipment for 3,000 lines and not 300 as stated in error.

We learn that Mr. F. Morley Ward, M.I.E.E., who until recently was General Manager (and previously Chief Engineer) of the Relay Automatic Telephone Co., Ltd., has now taken up a position in Spain with the International Telephone and Telegraph Corporation.

Mr. Ward will be well known to our readers; he was transferred from the N.T. Co., and in 1913 resigned from the Department to join the Marconi Co., who had acquired world wide patents for the Betulander (Electro Mechanical) Auto. Telephone System. Improvements in this system subsequently led to Betulander's invention of the Relay System and Mr. Ward, as the Co.'s Chief Engineer, was responsible for developing this system to meet British requirements.

The Journal has lost a very good friend and one of its best workers in the person of Mr. J. W. Gladwell, of the Messengers Lobby, E.-in-C.O., who unfortunately met with a fatal accident while cycling to the office one morning in February. Mr. Gladwell was our direct agent for many years at headquarters and also kept the general stock. He was most methodical in his methods and enthusiastic in his efforts to further the interests of the magazine. An old soldier, who had been quartered for years in India, Mr. Gladwell joined up for the period of the great war and served in the R.E. Postal Section in France. He came back matured in judgment, full of wise saws, and maintained our stock

like a real "quarter bloke." Mr. Gladwell leaves a widow and large family to whom our fullest sympathy is extended.

Mr. J. E. Taylor, S.E., Reading, read an interesting and original paper on "The Propagation of Electric Waves" on Wednesday, the 17th February, before a large audience at the Society of Arts. An animated discussion followed; in reply, Mr. Taylor suggested that the contents of the paper should be allowed to sink in before final judgment is passed.

A summary of Telegraph and Telephone progress during the last two years appeared in the January issue of the *I.E.E. Journal*. We recommend it to our readers, as it gives valuable information on the problems and scope of the work carried out by the Engineering Department of the P.O.

HEADQUARTERS NOTES.

Exchange Development.

The following works have been completed:—

Exchange.	Type.	No. of Lines.
Gosport	Auto.	600
Hayling Island	,,	200
Shrewsbury	,,	870
Aberdare	Manual.	360
Abertillery	,,	140
Bognor	,,	760
Brighouse	,,	440
Colchester	,,	210 additional
Cowes	,,	1700
Grangewood	,,	1520
Hoylake	,,	320
Huddersfield Extension ...	,,	720
Oswestry	,,	600
Pinner	,,	380
Redditch	,,	320
Rossendale Extension ...	,,	460
Todmorden	,,	300
Woking Extension ...	,,	380
Bank of S. Africa ...	P.A.B.X.	100
Barrow Hepburn & Gale...	,,	70
Bilsland Bros.	,,	40
Birkenhead Corporation...	,,	100
Bradford Newspaper Co....	,,	60
B.B.C. Birmingham ...	,,	30
British Mannesman Tube Co.	,,	40
Cooper's Store, Liverpool.	,,	20
J. Hall & Sons	,,	30
Jarrett Rainsford ...	,,	40
Liverpool Courier Extn....	,,	20
Manchester Corporation ...	,,	30

Exchange.	Type.	No. of Lines.
The Observer Ltd. ...	P.A.B.X.	30
Prices Candle Co. ...	,,	70
Sharpe & Sons	,,	30
Shell-Mex, Brixton ...	,,	30
Shell-Mex, Cardiff ...	,,	30
Taylors Drug Co. ...	,,	40
Tyldesley U.D. Council...	,,	20
United Water Softeners ...	,,	30
Vulcan Foundry	,,	40
Willis Faber Extension ...	,,	30

Orders have been placed for the following new Exchanges:—

Exchange.	Type.	No. of Lines.
Armley	Auto.	700
Basford	,,	1380
Keighley	,,	1300
Leicester	,,	8604
Nottingham	,,	7130
Sandal	,,	250
Syston	,,	130
Wakefield	,,	941
Western	,,	6800
Western Park	,,	205
Wigston	,,	250
Dartford	Manual.	560
Letchworth	,,	640
Manchester Relief ...	,,	5800
Newcastle Relief	,,	2600
Ashton-under-Lyme Infirmary	P.A.B.X.	30
Auto Strop Co.	,,	30
Bain & Son	,,	30
Birmingham Chamber of Commerce	,,	40
Birmingham Corporation..	,,	30
Blake & Co.	,,	40
Bradford Royal Infirmary	,,	40
Bristol Docks	,,	60
Collins & Co.	,,	20
Eastbourne Corporation ...	,,	50
Failsworth Co-op ...	,,	50
Hawkes & Son	,,	50
Kendal Milne Co. ...	,,	100
Lambeth Council ...	,,	50
Manifoldia Ltd.	,,	30
New Hudson Ltd. ...	,,	30
Newton Chambers & Co...	,,	100
North West Road Car Co.	,,	30
Perfecta Tube Co.... ...	,,	30
Robinson Bros.	,,	30
Spillers & Bakers ...	,,	40
Stewart Thompson & Co.	,,	40
United Water Softeners...	,,	30
Valor Co.	,,	30
Watney Coombe Reid ...	,,	130
Weston-super-Mare Council	,,	30
Wilson Wright Davies ...	,,	30
Yardley & Co.	,,	50

Orders have been placed for extensions to existing equipments as follows:—

Exchange.	Type.	No. of Lines.
Grimsby	Auto.	940
Marton	,,	100
Portsmouth	,,	—
Sketty	,,	170
Birmingham (East) ...	Manual.	380
Douglas (Glasgow) ...	,,	1820
Jesmond	,,	1240
Leeds Trunk	,,	—
Mansfield	,,	220
Mill Hill	,,	160
Paddington	,,	1000
Park	,,	2540
Romford	,,	320
Sydenham	,,	1580
Wimbledon	,,	1400
Willis Faber & Co. ...	P.A.B.X.	30

The installation of Leeds Telephone Repeater Station is well in hand, while work is also proceeding at Edinburgh, Jedburgh, Newcastle, Catterick, Birmingham, Gloucester and Newport stations. An installation of 2-wire repeaters is being fitted at Southampton Repeater Station to provide for extending the London—Southampton cable to Bournemouth. Engineering arrangements have been carried out at Aldeburgh for a night service circuit between London and Berlin.

Traffic Metering in Automatic Exchanges.

In manual exchanges, such traffic records as cannot be taken by means of the subscribers' meters can usually be obtained without undue difficulty by the operating staff.

With the introduction of automatic working, by which the majority of the calls are effected at the exchanges without human agency, these means are not available and special methods have to be adopted. The traffic records required in automatic exchanges may be divided into four main classes:—

1. Records of the effective calls originated by subscribers. These have, of course, been taken from the inception of automatic telephony in this country, as they are the basis of subscribers' accounts. They are mentioned here for completeness, and also because they may be used to supplement other records.

2. Records of the number of calls which fail to mature on account of insufficiency of switching plant. This is a measure of the service given to the public from the traffic point of view, *i.e.*, it is a measure of the quality of the product which the Telephone Department sells.

3. Records of the amount of traffic carried by the component parts of the exchange. This information is required to assist in design when an extension of the exchange is being planned.

4. Records of the total traffic carried by the exchange. These records are usually taken only quarterly and are required for general statistical purposes.

As regards the last three classes of records, a considerable number of records have been taken by actual observation at the switches. This method is tedious and is liable to cause interference with efficient maintenance. It has been considered desirable, therefore, to devise automatic means of taking these records, and although the final details of the various schemes have not been settled, enough has been done to enable complete metering schemes to be included in all the London exchanges and all future provincial ones.

LONDON ENGINEERING DISTRICT NOTES.

Mileage Statistics.

During the three months ended 31st December, 1925, the following changes have occurred:—

Telegraphs.—Nett decrease in Open Wire of 16 miles and a nett increase in Underground of 225 miles.

Telephones (Exchange).—Nett decrease in Open Wire (including Aerial Cable) of 258 miles and a nett increase in Underground of 30,278 miles.

Telephones (Trunks).—Nett decrease in Open Wire of 6 miles and nett increase in Underground of 2,258 miles.

Pole Line.—Nett increase of 82 miles, bringing the total to date to 5,272 miles.

Pipe Line.—Nett increase of 116 miles, the total to date being 6,385 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	24,393
Telephones (Exchange)	1,675,409
Telephones (Trunk)	59,918
Spares	48,638

External Construction.

During the quarter ended December 25th, 1925, 11,451 exchange lines, 7,273 internal extensions and 1,109 external exten-

sions were provided. In the same period 4,376 exchange lines, 3,015 internal extensions and 659 external extensions were recovered, making nett increases of 7,075 exchange lines, 4,258 internal extensions and 450 external extensions.

Internal Construction.

New Exchanges.—A new C.B.S. No. 2 Exchange equipment was brought into use at Upminster on January 14th. New exchanges are in course of construction at Primrose Hill (C.B.1, 4500 lines), Rodney—Walworth (C.B.1, 3700 lines), Waterloo—Hop Relief (C.B. 10A, 900 lines), and Kelvin—Western Relief (C.B. 10, 700 lines). The two first named Exchanges are being installed by the B.L.M. Ericsson Manufacturing Company and the General Electric Company respectively. The work in connection with Waterloo and Kelvin is being carried out by the District staff.

C.C.I.—The work at several of the manual Exchanges in the District at which C.C.I. equipment is to be introduced has been commenced.

Exchange Batteries.—Experiments have recently been carried out in the building up of batteries which have for their connections a lug and short bus-bar instead of the usual bus-bar which connects up positive plates in one cell to the negative plates in another cell. The new scheme is one which will enable cells to be rapidly erected, and will permit of sections which become faulty in existing cells to be replaced readily. The plates are standardized and at present about five various capacities are being dealt with. The lugs are merely bolted together, and no lead burning is necessary. The batteries dealt with in London up to the present are Paddington, Lee Green, Putney and Gerrard, and, so far as can be seen, the new arrangements, which have been designed by the Engineer-in-Chief, Telephone Section, will result in simplification and efficiency with economy. Lead-lined wood boxes are employed.

Wireless Induction.—An unusual fault which occurred recently affected the wireless aerials concentrated on G.P.O. West. Heavy induction was observed, and, from the frequency of the interruptions, the trouble was apparently due to a Baudot set. As, however, there are about 70 sets in use, neither the particular set nor the actual cause could be traced for some time. It was found necessary to start each Baudot separately, on a Sunday, when the trouble was finally traced to sparking at the contacts of a newly-devised receiver, which was in experimental use. Morse could be read by telephone while the induction existed, but mechanical reception was interfered with.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

ADMISSION of Post Office Candidates to the Institution of Electrical Engineers (approved by Membership Committee, 1923, and confirmed at meeting of 20th January, 1926).

Official Rank.	*Eligible for*
Staff Engineers	Full membership without examination.
Superintending Engineers ...	
Assistant Staff Engineers ...	
Assistant Suptdg. Engineers	
Executive Engineers ...	
*Assistant Engineers:	
(1) Recruited by open competition, or	After 5 years' service: Full membership without examination.
(2) Possessing exemption qualification	Otherwise: Associate membership without examination.
(3) Not recruited by open examination nor possessing exemption qualification	Associate membership after passing Part 2 of examination.
*Chief Inspectors and *Inspectors:	
(1) Possessing exemption qualification	Associate membership without examination.
(2) Not possessing exemption qualification	Associate membership after passing Part 2 of examination.

* Subject to 2 years' substantive service as Inspector, Chief Inspector or Assistant Engineer.

The foregoing defines "eligibility" only and has to be taken in conjunction with the byelaws of The Institution of Electrical Engineers.

LOCAL CENTRE NOTES.

NORTHERN CENTRE.

On the 2nd December last a party of members visited the Ropeworks of Messrs. Hood, Haggis & Co., at Willington

Quay-on-Tyne. The visit was very enjoyable and was rendered interesting and instructive by the courteous guidance and explanations of the Works Manager and his Assistant, to whom our members are very much indebted. The refreshments provided by the firm after the tour of inspection were much appreciated.

On the 20th January, 1926, Mr. C. Robinson, B.A., A.M.I.E.E., of the Engineer-in-Chief's Office, delivered a very instructive lecture, illustrated by lantern slides, on the subject of "Telephonic Repeaters and their Maintenance," before a well attended meeting. The points raised in the brisk discussion which followed the lecture were dealt with by the lecturer in an expert manner and the meeting in according a vote of thanks to Mr. Robinson voiced its appreciation in no uncertain manner.

On the 17th February, Mr. F. W. Longmore read a paper on "The Elements of Telephone Machine Switching." The paper dealt with the first principles of Automatic Telephony and was recognised by the meeting as a simple and useful introduction to the further study of automatics. A pleasing feature of the discussion which followed the reading of the paper was the increased participation of the junior members. A vote of thanks to Mr. Longmore was carried with hearty applause.

The Institute of Public Administration has extended an invitation to the members of this Centre to attend a Lantern Lecture to be given in the Mining Institute, Newcastle-on-Tyne, on Wednesday, the 24th February, at 7 p.m. The subject is "The P.O. Engineering Department and its Work," and the lecturer our respected chairman, Mr. J. R. M. Elliott, M.I.E.E.

It is with mingled feelings that we have to record the transfer of Mr. Charles Whillis, M.I.E.E., from the Technical Section, Superintending Engineer's Office, Newcastle-on-Tyne, to the Construction Section, Engineer-in-Chief's Office, on the occasion of his promotion to the rank of Assistant Staff Engineer. Pleasure in his promotion is tinged with regret at the loss of a man of outstanding personality and character coupled with a human understanding and sympathy with his fellow men.

Mr. Whillis's departure took place at short notice and precluded the possibility of arranging an entertainment at which to bid him goodbye, but a large number of members of the staff of the Northern District Engineering Department met in the Superintending Engineer's Office on the 9th March for the latter purpose and at the same time presented him with a Bureau of Chippendale period as a token of their good will and for remembrance.

The Chair was taken by Mr. J. R. M. Elliott, M.I.E.E., Superintending Engineer of the Northern District, who paid eloquent tribute to Mr. Whillis's ability as an Engineer and those personal

gifts which had endeared him to all those with whom he came in contact. Messrs. Baldwin, Andrews, Motyer and Cook expressed the congratulations of the staff. Mr. Baldwin called attention to the fact that Mr. Whillis was the second officer from the Northern District who, within the last 3 months, was called to take up an important position on the Headquarter's staff.

In accepting the gift, Mr. Whillis paid generous tribute to the assistance which he had received from all branches and referred particularly to the good relations and friendly spirit which had always existed between the various sections of the Northern Engineering District, a spirit which appeared to permeate those who came into the District as well as those who had grown up in it.

H.R.J.D.

SCOTLAND WEST CENTRE.

At the third meeting of the current Session, held on 7th December, 1925, in the Royal Technical College, Mr. J. Hardie introduced our new Chairman, Mr. R. Aitken.

The lecturer for the day was Mr. J. D. McLeod, the subject being "Main Cables: Loading, Testing and Transmission." The paper gave a brief explanation of the tests made on Loading Coil Sections of Main Loaded Cables and the result of these tests in order to meet the conditions aimed at in balancing.

The paper went on to describe the further tests made on groups of Loading Coil Sections when circuits are loaded for phantom working, in order to reduce the cross-talk between "phantom" and "side" as well as between "side" and "side" circuits. The acceptable values in each of the tests—insulation, conductor resistance, capacity unbalance, and cross-talk—were explained, and a brief summary was also given of the tests made on the completed cable to prove that the inductance added to the cable by the loading coils is up to specification and that the cross-talk is not unduly increased by the joining up of the loading coils; also that the standard of transmission aimed at by loading is attained.

The meeting arranged for 1st February had to be abandoned as one of the lecturers, owing to unforeseen circumstances, found it impossible to deliver his lecture.

NORTH EASTERN CENTRE.

The membership of the Leeds Branch has now passed the century mark and the Session just terminated has been most successful.

Lectures have been given on:—

"Telephone Exchange Accommodation."
"Manufacture and Testing of Earthenware Conduit."
"From Youth-in-Training to Engineer."
"Cable Faults—Causes and Remedies."
"Recruitment and Promotion of Staff."
"Slide Wire Bridge Testing."

Five of the six lectures were illustrated by lantern slides and the general opinion is that illustrated lectures are the most interesting and helpful. As will be readily understood from the titles quoted above, the field has been a varied one, many difficult ditches and hedges have been negotiated and at times it has been necessary for the M.F.H. to call the "hounds off," otherwise in their thirst for knowledge the hunt would have gone far into the night.

What is the Institution doing? Well, in this District it can with truth be said: (1) The Institution is bringing gentlemen together whose only other connection is "on paper," and as a result of the meeting in the flesh a better understanding amongst men is the result. (2) The Institution is giving to each member a synopsis of other work outside his own, thus placing him in a better position to more thoroughly understand the comprehensive work the Department is engaged upon. (3) The Institution is giving confidence, inasmuch as it affords an opportunity for men to speak in public on a subject on which they have specialised knowledge. (4) The Institution brings before each member the latest development in any phase of its work, so that all its members are kept interested and in touch with the progress of the "Science of Communications," which is so rapid as to make it impossible for any one member to be a specialist in all its branches.

The Staff is now recognising the real value of the Institution and the attendances and discussions are most satisfactory.

SOUTH MIDLAND CENTRE.

There was an attendance of 54 at the first meeting of 1926, held on the 26th January. Mr. V. Smith read his essay, "New ways of doing old jobs," which gained the first prize at the first essay competition for workmen held at the end of 1923.

Mr. Smith explained at the outset that his paper was written before he had gained experience as a supervisor.

His first suggestions for improving efficiency were in the wiring of tag blocks and in wiring apparatus when tees were necessary. With the aid of admirable sketches, a new method of wiring tag blocks at the top of 120 line C.B.S. lamp signalling switchboards was clearly explained. An arrangement for running several lead

cables branching off to different points was set out and a simple device for ensuring that the screw of a rack and the hole in a switchboard are in alignment was described.

Mr. Smith next dealt with a method of fitting rows of ceiling brackets and after mentioning the difficulties attending the use of rawl plugs, described a jig the introduction of which he claimed would overcome most of them.

There was no lack of questions. A paper full of practical suggestions was assailed with a stream of practical questions, to which the lecturer replied. Messrs. Campbell, Atkins, Bolton, Gravill, Dwyer, Harris and the Chairman joined in the discussion, and Mr. Smith realised that a feature of the history of inventions —the simultaneous discovery of a new idea—also applied to some of the results of his own enterprise.

Each speaker congratulated the lecturer and more than one of them emphasized the utility of papers of this type. The Chairman closed the meeting with a cordial expression of the thanks of the hearers.

Eighty-two members and visitors severely taxed the accommodation in the Physics' Lecture Room at the University College, Reading, on the occasion of the 56th meeting, held on March 3rd.

It had been arranged for Mr. J. S. Brown to read a paper entitled "The Training of Staff for, and Maintenance of, Automatic Telephone Exchanges," but owing to the numerous and insistent requests for a lecture on the principles of "Automatics" before his retirement at the end of March, Mr. Brown kindly undertook to take as read the paper on "Training, etc.," copies of which had been circulated, and proceed to answer questions thereon. That portion of the paper which dealt with training commenced with an account of the tuition at Portsmouth in 1914 and details of the 27 months' course were given. The six training duties scheduled at the present time for Portsmouth and Southampton were described.

The method of recruitment and the qualifications required of young applicants for training were detailed. Mr. Brown dealt with the maintenance of automatic apparatus under four headings —cleanliness, arrangement, organisation and routine—and very valuable information was imparted under each of the quartette.

The questions asked by Messrs. Atkins, Moody, Beaumont and the Chairman received adequate replies.

At this stage Mr. Halton eulogized Mr. Brown's work for the Institution and referred to the large number of helpful papers he had prepared.

Mr. J. S. Brown then commenced on the subject of "The Principles of Automatics."

A strong plea was made at the outset for members to study

automatic telephony which, the lecturer emphasized, was undoubtedly the system of the future. A very amusing account followed of the impressions gained by a journalist possessed of an unusually vivid descriptive powers on a visit to the Torquay Exchange.

The lecture, delivered in an easy unhesitating style, was given without notes and was illustrated by diagrams, sketches and a skeleton set. Reference was made to the early arrangement invented by Strowger and the kernel of all step by step system—a cylinder surrounding an axis capable of vertical and horizontal motions—was carefully explained. The refinements required for two, three, four or more digits were touched upon, and the introduction of Keith line switches and preselectors and later rotary line switches were explained. The use of rotary switches in key impulse senders and the storing of impulses was demonstrated by using a bank of preselectors.

The use of the transmission bridge and the principles of the register were ilustrated and the necessity proved for the eleventh point on the private banks. The problem of faults was investigated.

Replies were given to the questions put by Messrs. Halton and Beaumont, and Mr. Atkins thanked the lecturer for a three months' course received in an hour, which sentiment was echoed by other listeners.

In the absence of the Chairman, who had to leave the meeting at the close of the lecture, the Vice-Chairman thanked Mr. Brown on behalf of the large audience and expressed the hope that he would continue to give his valuable papers after the termination of his official duties for the Department.

The members present, by loud and prolonged applause, upheld this valedictory expression of the Vice-Chairman.

A.W.L.

RETIREMENT OF MR. T. E. P. STRETCHE.

On the occasion of his retirement from the service, Mr. T. E. P. Stretche, Superintending Engineer of the North Western District, was entertained by the members of his staff and other friends and colleagues in the service at a Smoking Concert held in the Victoria Hotel, Preston, on the evening of 3rd March, when he was presented with a William IV. silver tea and coffee service. Mr. J. S. Terras, Assistant Superintending Engineer, presided over a large company and among many others present were Mrs. Stretche with other ladies, and Messrs. T. B. Johnson (Superintending Engineer, N.E. District), W. J. Medlyn (Superintending Engineer,

S.Lancs. District), V. R. Kenny and A. E. Stocker (Assistant Surveyors, N.W. District), J. T. Whitelaw (Telephone District Manager, Manchester), S. O. Allen (Telephone District Manager, Blackburn), R. T. Vity (Postmaster of Preston), J. Curran (Postmaster of Southport), T. J. Collins (Postmaster of Wigan), F. W. Best (Executive Engineer, Rochdale), S. Upton (Executive Engineer, Blackburn), W. J. Rolfe (Executive Engineer, Preston Technical Section), J. T. Bramwell (Executive Engineer, Lancaster), and Mr. R. A. Jones (Staff Officer, Preston).

After the National Anthem had been sung, the Chairman read apologies for absence and expressions of good wishes from Colonel T. F. Purves, O.B.E. (Engineer-in-Chief), Messrs. A. L. DeLattre, J. Sinnott, O.B.E., and E. H. Shaughnessy, O.B.E. (Assistant Engineers-in-Chief), Mr. Randall Bell (Surveyor, N.W. District) and several other gentlemen, including a very delightful letter from Mr. J. W. Sullivan, late Assistant Superintending Engineer in the N.W. District.

Mr. Terras in making the presentation, after mentioning that Colonel Purves was greatly disappointed at not being able to come himself to Preston to make it, referred to Mr. Stretche's ability as an administrator and to the feeling of confidence, respect and affection which his staff entertained towards him. He remarked that outstanding qualities in Mr. Stretche's work in the N.W. District had been his regard for the position and prestige of the Engineering Department in its relation with other branches of the Public Service and with the outside world, his concern for seeing that engineering officers in the various towns had adequate and suitable office accommodation, his skill in conducting negotiations for the Department and particularly his constant endeavour to treat all members of his large staff with the most scrupulous fairness. After observing that Mr. Stretche was going away in vigorous middle-age with the capacity for getting much enjoyment out of existence for many years to come in his new home in Shropshire and that the good wishes of the staff extended equally to Mrs. Stretche, Mr. Terras made the presentation in a scene of much enthusiasm, the health of Mr. and Mrs. Stretche being drunk with musical honours.

Mr. F. W. Best, in paying a special tribute on behalf of the engineering officers in the District, referred to Mr. Stretche's high reputation as a chief who looked after the interests of his staff and to his charm and goodheartedness.

Mr. R. A. Jones paid a similar tribute on behalf of the clerical staff in the District: he made reference to Mr. Stretche's high conception of the dignity of the Civil Service and to the way in which he had upheld its best traditions.

Mr. Stretche, in responding, said words really failed him to

express adequately the feelings of Mrs. Stretche and himself on receiving so handsome a present and such a demonstration of affection from the members of his staff and his other old friends in the service. He thanked the staff of all ranks for the splendid service they had rendered to the Department through himself and said that no man could have been surrounded by a more loyal or conscientious staff. He ended by expressing his warmest wishes for the future success of every member of the staff and extending a hearty invitation to everyone to visit Mrs. Stretche and himself after they had settled down at Church Stretton with the single proviso that they did not all arrive on the same day!

Mr. S. Upton in a humorous speech proposed the health of the guests, and this was responded to by Mr. T. B. Johnson—a very old friend of Mr. Stretche, who gave some amusing reminiscences of their early days together in the service—and by Mr. R. V. Kenny, Mr. R. T. Vity, Mr. J. T. Whitelaw and Mr. S. O. Allen.

During the evening a capital musical programme, arranged by Mr. C. H. H. Bott, was carried through, the gentlemen taking part, who were all members of the staff, being Messrs. T. H. Tootell (flautist), C. G. Holland, J. Kelly, F. H. Lee, G. S. Powney, V. G. Dean, D. Barratt, W. Crookes, T. L. Abberley, H. S. Turner and R. B. Austin (vocalists), A. W. Field (monologue) and H. Horrocks and W. Nelson (humorous songs).

During the evening, Miss C. A. Roberts, senior typist in the Superintending Engineer's Office, presented Mrs. Stretche with a bouquet of pink carnations.

Mr. R. H. Ellis (with Mr. R. B. Austin as deputy) very carefully discharged the duties of honorary secretary and treasurer in connection with all the arrangements.

THOMAS EDWARD PRICE STRETCHE.

WITH the retirement of Mr. Stretche there passes from the service one of the best known and most popular men in the Engineering Department.

Entering the service at Gloucester in the autumn of 1880, about six years later Mr. Stretche joined the staff of the late Mr. A. W. Heaviside, I.S.O., then Superintending Engineer at Newcastle-on-Tyne. Some idea can be formed of the vast change which has taken place in the scope of the work since those days when one learns that the entire staff in the Superintending Engineer's Office at Newcastle consisted of five clerks. In other provincial Districts it was only four. As is well known, the Post Office had a telephone exchange system in Northumberland and Durham in very early days, and the experience which Mr. Stretche gained there relieving engineers was to prove valuable to him at

the Telephone Trunk Transfer in 1896, and later in connection with the telephoning of London by the Post Office, also still later when the National Telephone Company's system was taken over in 1912. Service at Newcastle was succeeded by short periods on the staff of the Supjerintending Engineer (Mr. Jenkin) at Cambridge, in the office of the Engineer-in-Chief and at Mount

THOMAS EDWARD PRICE STRETCHE.

Pleasant Factory in London. In 1893 Mr. Stretche became an Engineer, 2nd Class, in the Scotland West District, first under Mr. Ashton and afterwards under Mr. Stewart. Seven years' service in Glasgow was followed by a transfer to London in May, 1900, as 1st Class Engineer, and early in 1904 Mr. Stretche was

offered the post of Assistant Director of the Egyptian Government Telegraphs by Mr. (later Sir) John Cameron Lamb, but this was declined for domestic reasons. Very shortly afterwards Mr. Stretche was appointed Technical Officer on the Engineer-in-Chief's staff and had the responsible task of organizing the newly-formed Contracts Section. About this period there was great activity in laying underground lines for the more important telegraph routes, such as to Scotland and the West of England, also the telephoning of London, and it fell to Mr. Stretche's lot as head of the Contracts Section to have through his hands the work of preparing specifications, inviting tenders and placing contracts for these works, also arranging details with the various local authorities regarding re-instatement. Further advancement came in 1907 when he succeeded the present Engineer-in-Chief as Assistant Superintending Engineer in the old Southern District, which was then in charge of the Royal Engineers (K Company), and on the Royal Engineers' departure to Dublin was Assistant Superintending Engineer in the South Eastern District under Mr. Moir. In 1911 Mr. Stretche was appointed the first Superintending Engineer of the newly formed North Western District with headquarters at Preston. Offices for the latter had to be found, and also new offices for Sectional Engineers at Rochdale, Preston, Blackburn, Lancaster and extended accommodation at Carlisle, tenancies for which were negotiated by Mr. Stretche personally and proved to be a great improvement on the accommodation usually provided for Superintending Engineers' and Sectional Engineers' Staff elsewhere.

The clerical staff for the new District, which was drawn from all parts of the country, started work temporarily at Manchester, pending occupation of the Preston premises, the removal actually taking place on December 27th, 1911, a sorry date for a removal.

The fourteen years spent in the North Western District have been a busy period, the work carried out including the opening of 3 automatic and 14 C.B. Exchanges and the laying of a complete network of main cables between the principal towns.

Fond of open-air life, Mr. Stretche has played cricket for Gloucester, Northumberland and the West of Scotland: he played football also in Gloucester and when in Newcastle was Secretary of the Northern Rugby Football Club. In later years he has played golf and when in form is a strong man off the tee.

Mr. Stretche took a lively interest in the old Volunteer Forces, serving in the Gloucester Artillery and later, in Scotland, first in the Lanark Artillery and afterwards in the Highland Light Infantry. He has also been a member of the Senior Constitutional Club in London for over twenty-five years. Mr. Stretche is interested in Freemasonry, being at present Worshipful Master of

Lodge No. 314 and Scribe E of the Royal Arch Chapter. As all his friends know, Mr. Stretche is an authority on the subject of old furniture and old buildings and he is finding scope for indulging this excellent hobby in devoting the early days of his retirement to renovating and panelling out the Old Manor House of All Stretton, Church Stretton, Shropshire, where in the country of his forbears he has decided to make his home and where he has told us Mrs. Stretche and he will always be glad to welcome old friends.

In 1915 Mr. Stretche offered his services in a military capacity, but before this could be arranged he met with a serious motor accident whilst arranging for a tapping of German wireless in West Cumberland, sustaining a fractured arm and other injuries which incapacitated him for some time. He acted as Military Representative and later National Service Representative on the Recruiting Tribunal, for which he received the thanks of Lord Derby, then Secretary for War, Sir Auckland Geddes, Minister for National Service, the G.O.C. Western Command, etc., etc. He also commanded a Company and acted as Adjutant of the National Reserve.

Mr. Stretche was a distinct personality in the Engineering Department. Blessed by nature with a fine presence, with a habit of crisp and outspoken comment on men and things and with a great fund of humour, he was indeed well fitted to uphold the best traditions of the service. Few men could so quickly grasp the essentials of a case or argue it more convincingly. To those under him he was a fair and considerate chief, whose popularity with his staff was universal.

BOOK REVIEWS.

"Practical Electrician's Pocket Book. 1926." By H. T. Crewe. Cloth, pp. 585. Rentell, 3*s*. net.

The twenty-eighth edition of this well-known pocket book has been subjected to a very thorough revision. The bulk of the matter dealing with elementary principles has been entirely re-written, whilst new chapters on Power Factor Correction, Fault Localisation on Underground Cables, and Automatic Protective Gear have been added. We consider that it should appeal to a still wider circle of engineers and students than heretofore.

"Radio Year Book. 1926." Sir Isaac Pitman & Sons, Ltd. Pp. 182. 1*s*. 6*d*. net.

This is the fourth year of this interesting book. It deals largely with broadcasting matter, giving photographs and information concerning many of the B.B.C. staff at the different

stations, and of notable contributors to the success of the B.B.C. undertaking. A full list of broadcasting stations, including those in Australia, Canada and America, with their respective Call-signs and Wave-lengths is provided, and an excellent photograph among others of the 2LO masts on the roof of Selfridges.

"Insulated Electric Cables: Vol. I.—Materials and Design." By C. J. Beaver. London, Ernest Benn, Ltd. Pp. 264. 36*s*. net.

The author in his preface states that his object in writing this book has been firstly to supplement, balance, and focus the existing knowledge of the subject in order to guide and conserve the efforts of future workers, and secondly to promote among cable-users a wider knowledge of the properties of cables and a better appreciation of the reasons which govern the various types of construction and which determine the most suitable types for given duties. The present volume deals with Materials and Design, while a second volume is in preparation on the subject of Manufacture and Installation. As might be anticipated from its title the book deals with the subject more particularly from the Power Cable aspect, but much of the subject matter on materials is applicable to Telegraph and Telephone Cables.

After a short introductory chapter the author tackles the subject of Materials, dividing it under three headings, viz.: Conducting materials, insulating materials and, thirdly, protective and preservative materials. The subject is handled in a very thorough manner. The sources of supply, the characteristics both good and bad which render particular materials suitable or unsuitable in particular cases and the manufacturing processes through which these materials have to pass before emerging as finished products are minutely described.

One of the difficulties which the cable manufacturer has had to contend with is that in many cases he was compelled to purchase the components of his finished product in a comparatively late stage of manufacture and as a result he had in the past little or no control over the properties of these components, which in many cases are common articles of commerce such as cambric, paper, rubber and wax. Trouble from this cause has induced cable manufacturers to gradually extend their operations towards the source of their raw materials so that at the present time the majority of cable works include wire drawing and rubber mills, while some of the larger concerns go so far as to own controlled interests in rubber plantations, paper factories and lead and copper mines.

In dealing with materials the largest section is naturally devoted to insulating materials. At the present time the cable

user has the choice of roughly four types of dielectric, viz., rubber, paper, bitumen and varnished cambric, and of these the two first mentioned are by far the most generally used; the rubber being particularly suited for indoor low tension work, while paper has advantages for outdoor and general high tension work. Rubber, owing to its being attacked by ozone, is not to be recommended for use in situations where it cannot be protected from the effects of corona.

In the second portion of the book dealing with design a short preliminary chapter is devoted to the mechanical principles of design wherein among other points dealt with are notes on the behaviour of cables under tensile stress and the precautions necessary for the avoidance of twist.

A chapter then follows on the subject of conductors, wherein the properties of stranded conductors, their flexibility and make-up for various purposes are discussed. The forms and disposition of conductors, the advantages and disadvantages of shaped conductors and the grouping of conductors in special assemblies are among other things dealt with in this chapter.

Then follow two chapters on dielectrics, the first on composition design and the second on properties and limitations of dielectrics.

In regard to the choice of insulating papers all comparisons made by the author, whether bearing on electrical properties or on chemical properties, between papers of the pecto and ligno cellulose types, give results which are in favour of the former.

In dealing with the "mechanism" of breakdown of paper cables the author has established, as the result of experimental investigation, that the paper and impregnating materials usually employed are decomposed by simple destructive distillation at comparatively low temperatures with production of water. The moisture so produced is condensed on the interior of the lead sheath or absorbed by the contiguous paper forming an electrical weak path which will heat up and produce more water.

Much useful experimental work has been carried out by the author on rubber and the effects of different fillers and accelerators. As regards accelerators the author's experience, taking into account manufacturing and economic factors, is in favour of paranitrosodimethylaniline without the use of any inorganic accelerator. Vulcanised rubber, containing organic accelerators such as paranitrosodimethylaniline, have as good electrical properties and superior ageing properties compared with rubbers containing litharge and other inorganic accelerators.

The penultimate chapter in this interesting and comprehensive book is devoted factors in voltage rating. These are dealt with under the headings of potential gradient, grading and stress distortion.

A short chapter on sheaths completes the work to which a name and subject index is provided.

A book on cables might easily be dry and uninteresting, the

present work, however, is quite the opposite. It is written in an easily readable style, which conveys the maximum of information in the minimum of space and this is evidently due to the fact that the writer knows his subject perfectly from beginning to end. There are many other works on cables, but this book will be regarded as a standard work on the subject for many years to come. The printing and general get-up are worthy of the contents.

A. J. GILL.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Shackleton, J. M. ...	Asst. Supt. Engineer, London District.	Superintending Engineer, N. West District.	11-3-26
Best, F. W.	Executive Engineer, N. West District.	Asst. Superintending Engineer, N. Wales District.	To be fixed later.
Whillis, C.	Executive Engineer, N. District.	Asst. Staff Engineer, E.-in-C. Office.	11-3-26
Bannister, G. W. ...	Assistant Engineer. S. West District.	Executive Engineer. S. West District.	17-1-26
McCormack, W. ...	Assistant Engineer, N. West District.	Executive Engineer, S. Lancs. District.	7-2-26
Lockhart, J.	Assistant Engineer, Scot. West District.	Executive Engineer, Rochdale Section, N. West District.	To be fixed later.
Tebbits. J. E.	Assistant Engineer, N. Wales District.	Executive Engineer, Hanley Section, N. Wales District.	23-2-26
Lakey, E. A.	Assistant Engineer, E.-in-C. Office.	Executive Engineer, Telegraph Section, E.-in-C. Office.	23-2-26
Finlayson, W. J. ...	Assistant Engineer, N. West District.	Executive Engineer, Lancaster Section, N. West District.	To be fixed later.
Sharpley, A. J. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer, St. Albans Section, East District.	do.
McMullen, J. F. ...	Assistant Engineer, S. Wales District.	Executive Engineer, Southampton Section, S. Mid. Disrtict.	do.
Gibbon, A. O. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer, Telegraph Section, E.-in-C. Office.	3-4-26
Kirkwood, D. ...	Chief Inspector, S. Lancs. District.	Assistant Engineer, S. West District.	10-1-26
Kay, C. P.	Chief Inspector, N. District.	Assistant Engineer, Northern District.	24-12-25
Riley, J. H.	Chief Inspector, E-in-C. Office.	Assistant Engineer, E.-in-C. Office.	20-12-25
Snell, W. S.	Chief Inspector, Power District.	Assistant Engineer, E.-in-C. Office.	8-2-26
Willis, F. B.	Chief Inspector, E-in-C. Office.	Assistant Engineer, E.-in-C. Office.	To be fixed later.
Leech, W. H.	Third Officer, H.M.T.S. " Alert."	Second Officer, H.M.T.S. Alert.	1-11-25

PROMOTIONS—(continued).

Name.	Grade.	Promoted to.	Date.
Milton, G. P. ...	Inspector, London District.	Chief Inspector, E.-in-C. Office.	To be fixed later.
Gray, W. H. D. ...	Inspector, N. Wales District.	Chief Inspector, N. Wales District.	5-11-25
Davey, H. B. ...	Inspector, S. Lancs. District.	Chief Inspector, N. Wales District.	18-10-25
Monk, A. J.	Inspector, Testing Branch.	Chief Inspector, Testing Branch.	10-9-25
Wilmot, C. J.... ...	Inspector, S. Mid. District.	Chief Inspector, E.-in-C. Office.	To be fixed later.
West, A. S.	Inspector, E-in-C. Office.	Chief Inspector, E.-in-C. Office.	4-10-25
MacQueen, J. J. ...	Shift Officer, Oxford Radio.	Inspector, Oxford Radio.	13-1-26
Johnson, W. S. ...	,,	,,	5-1-26
Chislett, G. F. S. ...	Skilled Workman, Class I., S. Wales District.	Inspector, S. Wales District.	11-1-26
Clark, S. J.	,,	,,	18-1-26
Thatcher, E. J. ...	,,	,,	18-1-26
Taylor, G.	Skilled Workman, Class I., Scot. East District.	Inspector, Scot. East District.	7-12-25
Choldcroft, E. W. ...	Skilled Workman, Class I., Eastern Disrtict.	Inspector, Eastern District.	21-12-25
Leggatt, J.	,,	,,	19-7-25
Ragless, A.	,,	,,	25-11-25
Hamilton, H. ...	Skilled Workman, Class I. N. Ireland District.	Inspector, N. Ireland District.	22-9-25
Thompson, C.	Skilled Workman, Class I., S. Midland District.	Inspector, S. Mid. District.	18-10-25
Court, A. F.	,,	,,	10-12-25
Clatworthy, F. H. ...	Skilled Workman, Class I., Testing Branch.	Inspector, Testing Branch.	10-9-25
Mason, F. C.	Skilled Workman, Class I., N. Wales District.	Inspector, N. Wales District.	1-9-25
Ballard, W.	,,	,,	21-10-25
Kendall, H.	,,	,,	26-9-25
Blofield, J.	,,	,,	5-11-25
Connacher, A. ...	Skilled Workman, Class I., Scot. West District.	Inspector, Scot. West District.	1-7-25
Dodds, E.	Skilled Workman, Class I., Northern District.	Inspector, N. District.	1-1-26
Freestone, A. G. ...	Skilled Workman, Class I., E.-in-C. Office.	Inspector, E.-in-C. Office.	29-11-25
Matthews, W.	Skilled Workman, Class I., S. West District.	Inspector, S. West District.	To be fixed later.
McIver, T. G.... ...	Skiller Workman, Class I., Scot. West District.	Inspector, Scot. West District.	10-10-25
Dawson, A.	S.C. & T., Sheffield.	Repeater Officer, Class II., N. Wales District.	14-9-25

STAFF CHANGES.

APPOINTMENTS.

Name.	Grade.	Appointed.	Date.
Stretch, W.	Probationary Assistant Engineer,	E.-in-C. Office.	29-12-25
Owen, J. McA. ...	,,	,,	29-12-25
Jones, F.	,,	,,	1-1-26
Wylie, T. O. K. ...	,,	,,	23-12-25
Hodge, G. W. ...	,,	,,	29-12-25
Chapman, F. B. ...	,,	,,	22-12-25
Procter, W. S. ...	,,	,,	29-12-25
Morrish, H. E. ..	,,	London District.	29-12-25
Beach, W. R.	,,	E.-in-C. Office.	1-2-26
Straw, J. G.	,,	Testing Branch.	25-1-26
Tyson, W. R. ..	,,	E.-in-C. Office.	10-1-26
Jones, H. C.	,,	,,	8-1-26
Williams, H.	,,	,,	25-1-26
Tufnail, M. E. ..	,,	,,	12-1-26
Baines, J.	,,	Testing Branch.	31-1-26
Hollinghurst, F. ...	,,	E.-in-C. Office.	1-1-26
Edwards, J. J. ...	,,	Testing Branch.	18-1-26
Cox, H. E.	,,	E.-in-C. Office.	12-1-26
Morrill, A. E. ...	,,	Testing Branch.	1-2-26
Wright, F. V. ...	,,	,,	12-1-26
Cooper, M. C. ...	,,	E.-in-C. Office.	10-1-26
Reading, J.	,,	,,	31-12-25
Palmer, R. W. ...	,,	,,	12-1-26
Swift, R. E.	,,	,,	9-2-26
Hudson, A.	,,	,,	9-2-26

TRANSFERS.

Name	Grade.	Transferred.		Date.
		From	To.	
Cowie, J.	Executive Engineer.	S. Lancs. District.	London District.	31-1-26
Bramwell, J. T.	Executive Engineer,	Lancaster Section, N. W. District.	Northern District.	To be fixed later.
McLeod, J. ...	Chief Inspector.	S. Wales District.	Northern District.	1-2-26
Atkinson, J. W. ...	Assistant Staff Engineer.	E.-in.C. Office.	London District.	11-3-26

RETIREMENTS.

Name	Grade.	District.	Date.
Stretche, T. E. P. ...	Superintending Engr.	North Western.	10-3-26
Masaroon, R. G. ...	Asst. Superintending Engineer.	N. Wales District.	26-1-26
Newlands, T. H. ...	Executive Engineer.	E.-in-C. Office.	31-1-26
Waters, E. W. ...	Assistant Engineer.	London.	9-2-26
Brown, J. S.	Executive Engineer.	South Midland.	31-3-26
Whitehead, J.	Executive Engineer.	Eastern.	31-3-26
Harding, W. D. ...	Chief Inspector.	S. Wales.	25-12-25
Radcliffe, H. H. D. ...	Inspector.	Scotland West.	24-11-25

DEATHS.

Name.	Grade.	District.	Date.
Shepherd, G. M. B. ...	Executive Engineer.	E.-in-C. Office.	24-1-26
Giffen, A. E.	,,	North Wales.	3-2-26
Braine, P. S.	Inspector.	London.	16-11-25
Loughborough, A. R....	,,	,,	28-11-25
Holmes, J. W. ...	,,	N.E.	13-12-25

CLERICAL ESTABLISHMENT.

APPOINTMENTS AS CLERICAL OFFICER.

Name.	District.	Date.
Strain, W. J.	North Eastern.	17-1-26
Reid, R.	Scotland East.	17-1-26
Stanes, H. G.	London.	14-1-26
McConnell, J. F.	South Eastern.	12-12-25

RETIREMENTS.

Name	Grade.	District.	Date.
Roberts, G.	Clerical Officer.	S. Lancs.	31-12-25
Lima, F. A.	,,	,,	31-12-25
Nance, L. M.	,,	London.	31-10-25

BOARD OF EDITORS.

J. W. ATKINSON, M.I.E.E., Chairman.

E. H. SHAUGHNESSY, O.B.E., M.I.E.E., M.I.R.E.
Lieut.-Col. A. C. BOOTH, M.I.E.E.
B. O. ANSON, M.I.E.E.
E. H. M. SLATTERY.

W. CRUICKSHANK, M.I.E.E., Managing Editor.
J. J. MCKICHAN, Assistant Editor, A.M.I.E.E.

COMMUNICATIONS.

All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, Alder House, London, E.C.1.

Binding covers and copies of the Contents for Vol. 3 to 18 are available, and may be obtained from the local agents for 1*s.* 6*d.* and 3*d.* respectively. Subscribers can have their copies of Vol. 18 bound, with index included, at a cost of 3*s.* by sending the JOURNALS to the local agents. Orders should indicate whether the original binding with black lettering, or the later pattern in gold, is required.

The price of the JOURNAL is 1*s.* 6*d.* (1*s.* 9*d.* post free) per copy, or 7*s.* per annum, post free. All back numbers 2*s.* each.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

Officers of Colonial and Foreign Telegraph Administrations who are engaged in Electrical Engineering Works may be admitted as Colonial and Foreign Corresponding Members respectively, after application.

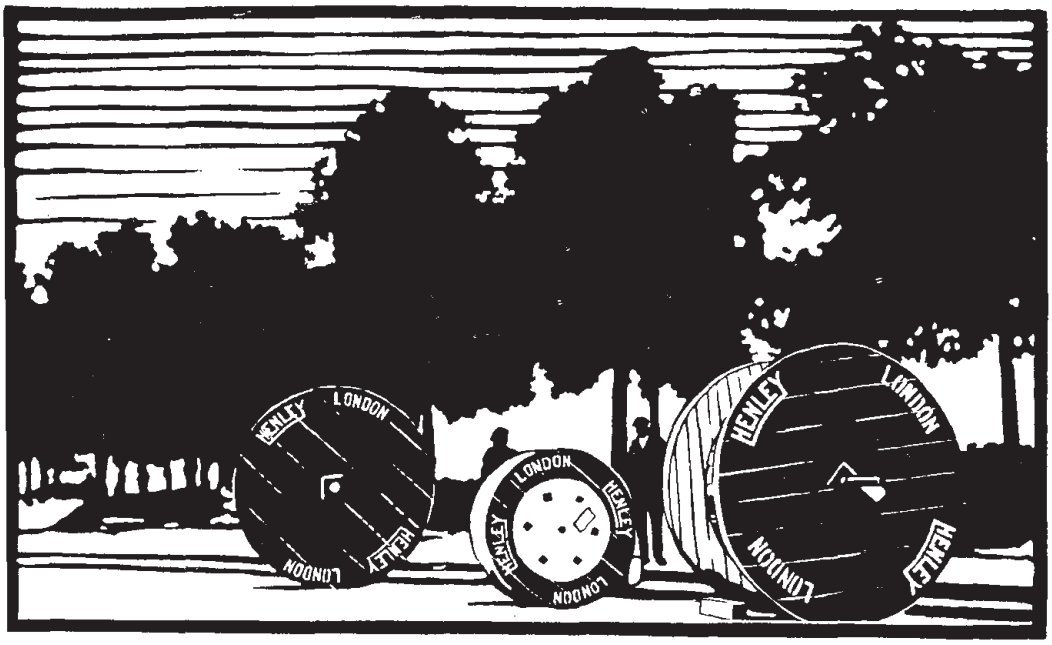
Subscription payable annually in advance on 1st April in each year:

Colonial Members £1 0 0
Foreign ,, ... £1 10 0

These sums include Annual Subscription to the Journal of P.O. Electrical Engineers and the supply of all Professional Papers issued during the period covered by subscription.

Forms of application for Colonial and Foreign Membership can be obtained on application to

The Secretary,
Institution of P.O.E. Engineers,
G.P.O., Alder House, E.C.1.



HENLEY

DRY CORE CABLES

THE concentrated experience of scores of capable men—chemists, physicists and cable makers—is applied to every length of Henley Telegraph and Telephone Cable, in a way which ensures satisfactory working in all conditions.

WE DRAW High Conductivity Electrolytic Copper Wire in all sizes, and can quote favourable terms.

W. T. HENLEY'S TELEGRAPH WORKS Co., Ltd.,
Holborn Viaduct, LONDON, E.C.1.

Manufacturers of Electrical Cables since the beginning of Electrical Transmission

559.

INDEX TO ADVERTISERS.

	PAGE
Automatic Telephone Mfg. Co., Ltd.	iii
British L.M. Ericsson Mfg. Co., Ltd.	v
Creed & Co., Ltd.	viii and ix
Henley's, W. T., Telegraph Works Co., Ltd. ...	xi
Johnson & Phillips, Ltd.	xvi
London Electric Wire Co. & Smiths, Ltd.	ii
N.V. Electriciteits Maatschappy "Zeva"	xiv
Peel-Conner Telephone Works, Ltd.	xv
Pitman & Sons, Ltd.	ii
Siemens Bros. & Co., Ltd.	vi and vii
Smith, Frederick, & Co.	xiv
Standard Telephones and Cables, Ltd.	x
Telephone Publishing Corp.	xii
The Electrical Review, Ltd.	iv and xii
Tungstone Accumulator Co., Ltd.	xiii

THE ELECTRICAL REVIEW.

To the progressive Post Office Electrical Engineer the "REVIEW" offers the best means of keeping abreast with modern developments, not only in his own section of the industry, but also in every sphere in which electricity is employed both here and abroad.

Price 6d. weekly.

THE ELECTRICAL REVIEW, 4, Ludgate Hill, London, E.C.4.

The Engineering talent

all over the world reads TELEPHONY because it helps them keep abreast of the important developments in the telephone industry.

Telephony.
THE AMERICAN TELEPHONE JOURNAL

has been the leading journal in its field for 25 years—a quarter of a century of valued service to its readers. Subscription price (foreign, including postage) $5.00. Issued weekly.

TELEPHONY PUBLISHING CORP.,
608 S. Dearborn St., Chicago, Ill., U.S.A.

THE ONLY ACCUMULATOR IN THE WORLD WITH PLATE-GRIDS MADE OF PURE LEAD

with the Plate Grids Die Cast and Pasted entirely by machinery. Without Wood Separators or Celluloid, eliminating internal resistance and heat which shortens the life of other makes of plates, and creating constant trouble.

TUNGSTONE
Pure Lead Grid
Accumulator

ROBUST Machine-made Plates permit charge and Discharge at Continuous High Rates with Safety. No possibilities of the Plates Buckling or short-circuiting in service. No Fire or Explosion Risks when Charging above Normal Rates. A Tungstone Battery is not fully charged unless the Acid shows fully 1300 Sp.G. Tungstone Robust Machine Made Plates are in best condition when always kept fully charged.

VERY IMPORTANT ADVICE TO MOTORISTS.

Arrange for Car Dynamo output to be permanently increased so that at a car speed of 20 miles per hour the continuous charging rate is as follows, viz.:

40 a.h. Battery minimum charging rate is 8 amps.
50 a.h. „ „ „ „ 10 amps.
75 a.h. „ „ „ „ 15 amps.

Tungstone Machine Made and Pasted Plates are Heavier and Stronger than any other make of Plate, and therefore can be continuously charged at these higher rates than any other make of battery.

Tungstone Plate Grids being made of Pure Lead, and the Paste of Pure Lead Oxides, ensures exceptional storage capacity and quick discharges, therefore provision is made to give continuous, ample and generous power for Self-starting without cranking.
Follow these instructions and you permanently get the full benefits of the originality of Tungstone Design and Manufacture of a Pure Lead Plate and Grid giving exceptional Strength, Storage, Dependability, Reliability, Security, and Safety.

CHARGING HIGH TENSION AT 12-16 VOLTS POTENTIAL.

All H.T. Tungstone Accumulators are fitted with a Patent Equipment whereby each series of 12 Volts can be coupled in parallel so that these H.T. Batteries of whatever voltage can be charged at local Garages and Charging Stations on a 12-16 Volt Low Tension Charging Plant.
Charging Terminals are provided on the front of the Cabinet arranged in two rows, the top row being Positive and the bottom row Negative. When in use these charging terminals are connected in pairs so that all cells are in series.

☞ **Apply for copy, sent post free, Illustrated Booklet—**
"Photography tells the Story of the Tungstone Accumulator."

Please address all communications to the Distributors' Offices and Showrooms:
TUNGSTONE ACCUMULATOR CO., LTD.,
3, ST. BRIDE'S HOUSE, SALISBURY SQ., FLEET ST., LONDON, E.C.4
Telegrams: "Typify, Fleet, London." Telephone: Central 8157 (4 lines).

SOLD BY ALL DEALERS. T.24

Series of Patent Designs and Trade Mark Issued or Applied for in the Chief Countries of the World.

FREDERICK SMITH & CO.,

Incorporated in

The London Electric Wire Co. & Smiths, Ltd.,

ANACONDA WORKS, SALFORD, MANCHESTER.

HARD DRAWN H.C. COPPER LINE WIRE.

Special Tinned H.C. Copper Wire.

COPPER TAPES AND BINDERS FOR LINE WIRE.

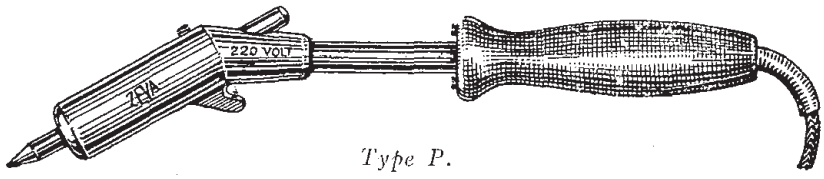
COPPER TROLLEY WIRE

SPECIAL NON-FOULING SECTIONS.

SILICIUM BRONZE WIRE

"C" Quality for Telephone Lines, &c.

Special Electric "Zeva," SOLDERING IRON for Telegraph and Telephone purposes.



Type P.

Electric "Zeva" Soldering Irons have no need of spare-elements. As a consequence the costs of maintenance are nil.

N.V. ELECTRICITEITS MAATSCHAPPY "ZEVA,"

AMSTERDAM (HOLLAND).

Telegraphic Address: "ZEVA."

PEEL-CONNER
"LONG-LIFE" CORDS

The economics of the telephone cord, whether for the subscriber's set or the switchboard, provide a useful field for study by the telephone maintenance engineer.

There is much more in the subject than at first sight appears. When tendered prices are under consideration prior to an order being placed a leaning towards the lowest price must very generally be felt. There comes into play, however, the maintenance cost, often considerable, of sending a mechanic to replace or repair a worn-out cord, and also the great damage to the reputation of the service resulting from the trials of the subscriber in the period during which the cord by "scraping" and "cut offs" is fitfully announcing its approaching end.

The greater the useful life of the cord the less frequent these two burdens become, and the resulting reduction in the annual maintenance costs and the improved relations with the telephone using public will many times outweigh the slightly greater first cost of the "Long-Life" cord.

For over four years the Peel-Conner "Long-Life" cords have been used by many telephone administrations all over the world. Even in tropical countries there are administrations that, having tested and proved the merits of our "Long-Life" cords, have settled on their use as the standard for the future.

Quotations and full details of Peel-Conner "Long-Life" Cords and Cordage will gladly be furnished upon application being made to either of the addresses below.

PEEL-CONNER TELEPHONE WORKS

(Proprietors—The General Electric Co., Ltd.)

COVENTRY, ENGLAND.

HEAD OFFICE AND WORKS:
STOKE, COVENTRY.
Telephone: COVENTRY 1310.
Telegrams:
"SPRINGJACK," COVENTRY.

LONDON OFFICE:
MAGNET HOUSE,
KINGSWAY, W.C.2.
Telephone: REGENT 7050.
Telegrams:
"Peelcontel, Westcent, London."

Half a century's experience

is built into every yard of Trunk Telephone Cable manufactured and supplied by us.

That such experience and the articles produced creates confidence among buyers is proved by our constantly increasing business is this direction.

The efficiency of the National Telephone service depends largely on J. & P. Cables because they are used in constantly increasing quantities, and that they are so used should influence larger and more frequent orders from the Dominion and other authorities.

It should influence *you* to a favourable consideration of the Cable distinguished by that "little more" in quality which means so much in service.

JOHNSON & PHILLIPS, Ltd.

Where the Cables come from.

Charlton, London, S.E.7.

Home Branches—

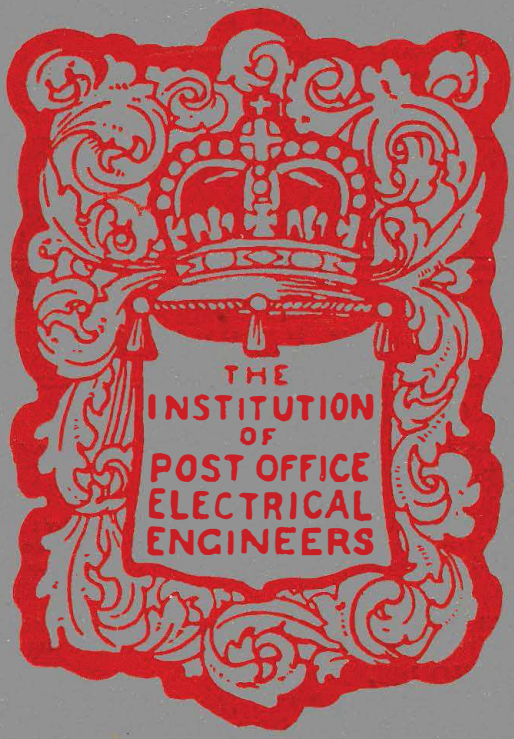
London (City), Birmingham, Bristol, Cardiff, Glasgow, Liverpool, Manchester, Newcastle-on-Tyne, Portsmouth & Belfast.

Overseas Branches and Agencies at—

Sydney, Melbourne, Rio de Janeiro, Calcutta, Bombay, Madrid, Wellington (N.Z.), Johannesburg, Durban and Singapore.

Printed by Birch & Whittington, Epsom, and
Published by The Electrical Review, Limited, at 4, Ludgate Hill, London, E.C.

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL



VOL. 19 PART 2

JULY 1926

Price 1/6 net.

ADVERTISEMENT INDEX
see page xii.

The

LONDON ELECTRIC WIRE CO. and SMITHS, LTD.

Manufacturers of

Every Description of Cables and - Wires for Electrical Purposes -

Cotton-Covered and Braided Wires. Cotton-Covered Strips and Cables. Silk-Covered and Enamel Insulated Wires. Multiple Cables. Flexible Cords. Cables and Flexibles for Wireless Work.

"Eureka," Nickelchrome and other High Resistance Wires.

Playhouse Yard, Golden Lane, London, E.C.1.

Telegrams: "Electric, London."
Telephone: Clerkenwell 1388, 1389, 1390, 1391.

Pitman's Books for Engineers and Students.

ELEMENTARY TELEGRAPHY.

By H. W. PENDRY. Second Edition. Specially written for candidates for C. & G. I. Examinations. 189 Illustrations. **7s. 6d.** net.

TELEGRAPHY.

By T. E. HERBERT, M.I.E.E., Assistant Superintending Engineer, Post Office Engineering Dept. A Detailed Exposition of the Telegraph System of the British Post Office. Fourth Edition. Revised and Enlarged. 1040 pages. 640 Illustrations. **18s.** net.

TELEPHONY.

By the same Author. This work contains full information regarding the Telephone Systems and Apparatus used by the British Post Office. 883 pages. 618 Illustrations. **18s.** net.

AUTOMATIC TELEPHONES.

By F. A. EDLSON, B.Sc. Hons. (Vict.), A.M.I.E.E., *Engineer, G.P.O.* An introductory treatise dealing with the fundamental principles, methods, and advantages of automatic telephony. 227 pages. 48 Illustrations. **5s.** net.

THE PRACTICAL TELEPHONE HANDBOOK AND GUIDE TO THE TELEPHONE EXCHANGE.

By JOSEPH POOLE, A.M.I.E.E., Wh.Sc. This book is recommended by the Examiners for the City and Guilds Institute Examinations in Telephony. Sixth Edition, 725 pages. 585 Illustrations. **15s.** net.

ARITHMETIC OF TELEGRAPHY AND TELEPHONY.

By T. E. HERBERT, M.I.E.E., and R. G. DE WARDT, *of the Post Office Engineering Department.* Suitable for candidates for City and Guilds Institute Grade I. Examination. 187 pages, 37 diagrams. **5s.** net.

RADIO COMMUNICATION, MODERN.

By J. H. REYNER, B.Sc. (Hons.), A.C.G.I., D.I.C., *of the Post Office Engineering Dept.* A manual of modern theory and practice, covering the syllabus of the City and Guilds Examination and suitable for candidates for the P.M.G. certificate. Second Edition, thoroughly revised. 220 pages. 121 Illustrations. **5s.** net.

THE BAUDOT PRINTING TELEGRAPH SYSTEM.

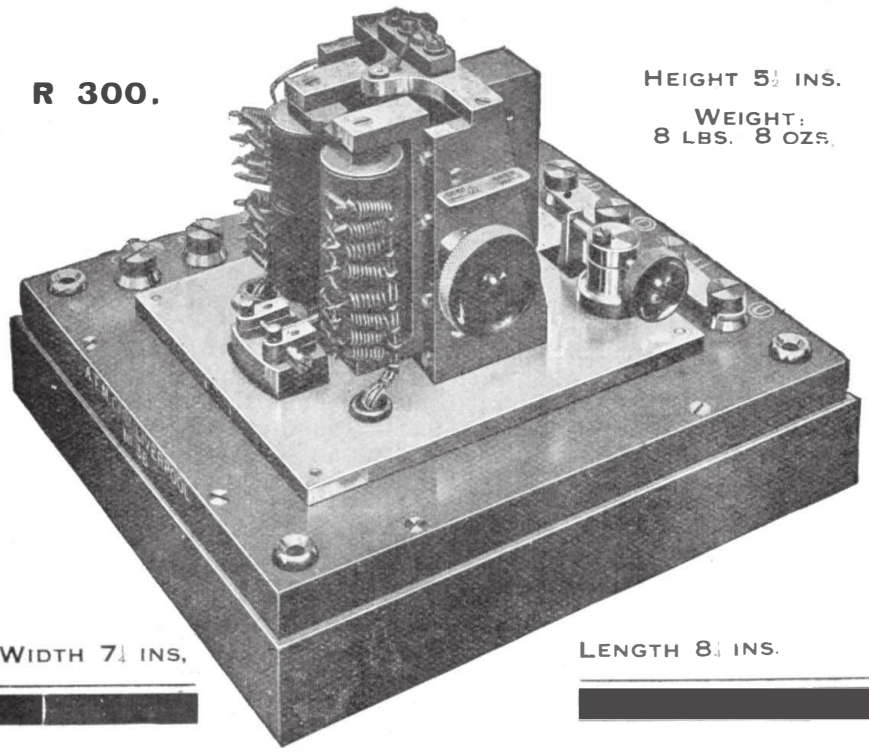
By H. W. PENDRY. Second Edition. With 72 illustrations of the latest models. **6s.** net.

Complete list post free: **PITMAN'S, Parker Street, Kingsway, W.C.2.**

R 300.

HEIGHT 5½ INS.

WEIGHT:
8 LBS. 8 OZS.



WIDTH 7¼ INS.

LENGTH 8¼ INS.

A.T.M.

GULSTAD RELAY

CABLE PATTERN

THIS pattern relay has been developed for specially difficult lines and submarine cables.

The adjustment of the contact carriage and the relation of the electromagnet cores to the armature system is of wide range and can be made in minute steps.

The frame in which the coils slide is very rigid and the relay is not susceptible to extraneous vibations.

SEND TO-DAY
FOR
CATALOGUE
No. 39.

AUTOMATIC TELEPHONE
MANUFACTURING CO., LTD.

Head Office and Works:

MILTON ROAD,
EDGE LANE,
LIVERPOOL.

London Office:

NORFOLK HOUSE,
NORFOLK STREET,
STRAND, W.C.2

The Post Office Electrical Engineers' Journal.

A QUARTERLY JOURNAL.

CONTENTS FOR JULY, 1926.

COPYRIGHT.—The entire contents of this Journal are covered by general copyright, and special permission is necessary for reprinting long extracts, but Editors are welcome to use not more than one third of any article, provided credit is given at the beginning or end thus: "From the 'Post Office Electrical Engineers' Journal.'"

	PAGE
SIMPLEX WORKING ON FAST SPEED REPEATERS	101
THE LONDON—GLASGOW TRUNK TELEPHONE CABLE AND ITS REPEATER STATIONS	103
LONDON—BERLIN TELEPHONE CIRCUIT	148
AUTOMATIC TELEPHONE EXCHANGES IN AMSTERDAM. MAINTENANCE EXPERIENCE—Dr. Ir. Ch. E. A. Maitland	153
TIME SAVING TESTERS FOR AUTOMATIC EXCHANGES—W. Prickett and H. S. Smith	174
TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM ...	178
A NEW TYPE OF FUSE MOUNTING FOR THE TERMINATION OF TRUNK, JUNCTION AND TELEGRAPH CIRCUITS—A. O. Gibbon, M.I.E.E.	179
THE PASSING OF BLACKFRIARS POWER STATION	185
THE TRAINING OF OFFICERS OF THE BRITISH POST OFFICE ENGINEERING DEPARTMENT IN PRECISION TESTING OF UNDERGROUND CABLES—A. B. Morice, B.Sc.(Eng.), A.M.I.E.E., and A. Morris, A.R.C.S., A.M.I.E.E.	189
ACCIDENTS ON DUTY—R. A. Jones	198
NOTES AND COMMENTS	208
HEADQUARTERS NOTES	214
LONDON DISTRICT NOTES	216
THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS ...	219
LOCAL CENTRE NOTES	220
BOOK REVIEWS	231
STAFF CHANGES	231
COMMUNICATIONS	234
ESSAY COMPETITION, 1925-26	234

All communications with regard to advertisements to be addressed to:

The Advertisement Manager,
Post Office Electrical Engineers' Journal,
4, Ludgate Hill, London, E.C.4.

PUBLISHERS:

THE ELECTRICAL REVIEW, LTD., 4, LUDGATE HILL, E.C.

Price 1/6 net, post free, 1/9. | **Annual Subscription, postage inclusive, 7/-, payable in advance.**

— and then he got a trouble-free 'phone system!

THE exasperating breakdowns, delays and muffled speech encountered on ordinary phone systems fade away when an Ericsson System is installed.

Trouble-free, clear-speaking and carrying a tiny maintenance bill, it proves a wonderful business aid and soon repays its moderate initial cost. Stands up wonderfully well to hard wear.

Write to-day for free fully illustrated and informative pamphlets.

ERICSSON TELEPHONES LIMITED
International Buildings,
67-73, Kingsway,
London, Eng., W.C.2.

WORKS: BEESTON, NOTTS

Telephone: Gerrard 3003, 3004

Telegrams: Ericsson, Westcent, London.

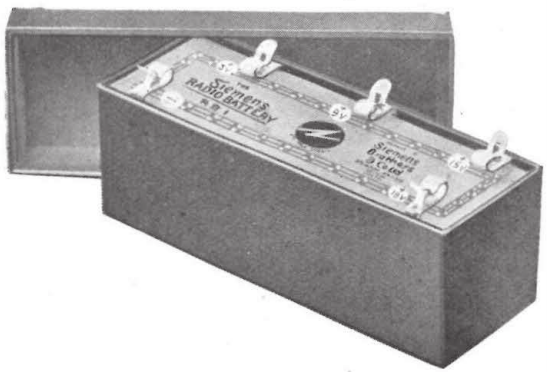
Ericsson

TELEPHONE EXCHANGE EQUIPMENT.

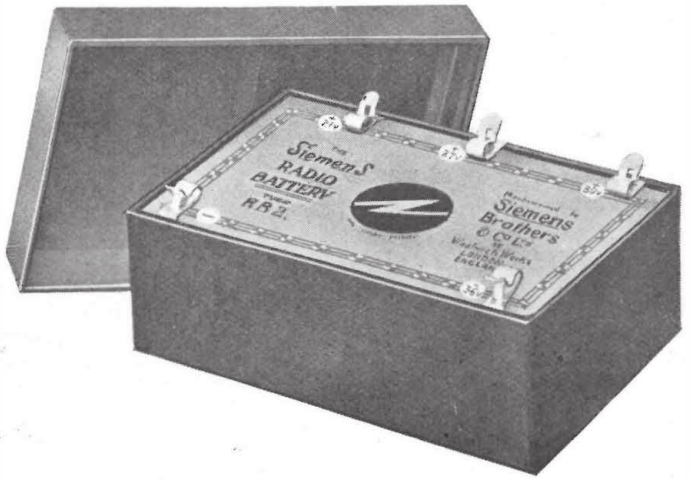
SIEMENS

H.T. DRY BATTERIES.

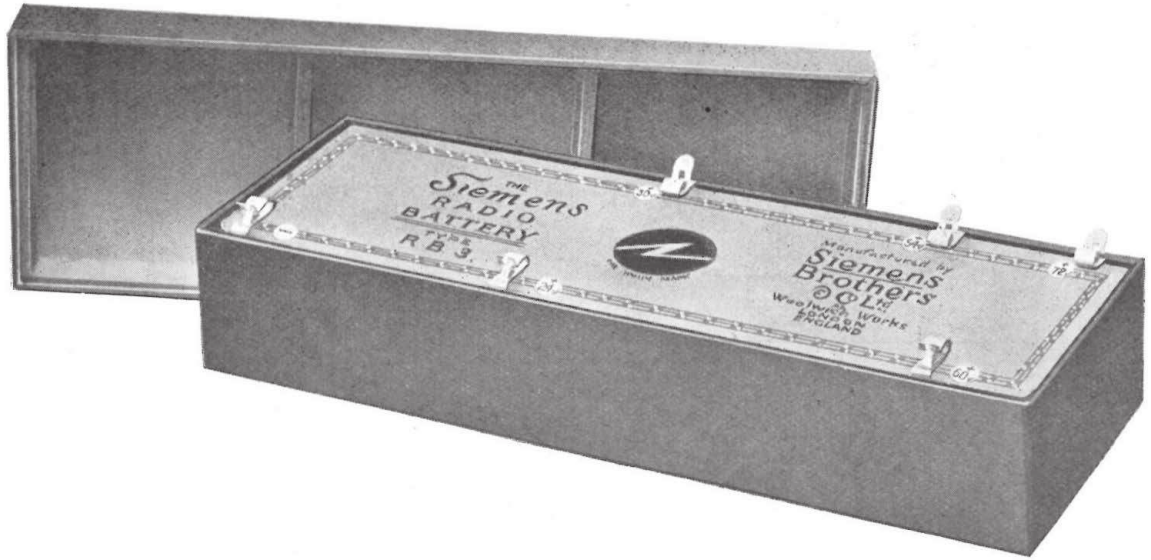
NEW TYPE—LARGE CAPACITY.



Type R.B. 1., 18 Volts.



Type R.B. 2., 36 Volts.



Type R.B.3., 72 Volts.

THESE H.T. DRY BATTERIES EMBODY ALL THE IMPROVEMENTS WHICH OUR EXPERIENCE OF THE REQUIREMENTS OF MODERN BBOADCAST RECEPTION HAS SHOWN TO BE NECESSARY.

Descriptive Price Sheet 645 will be sent on application.

SIEMENS BROTHERS & CO., LIMITED, WOOLWICH, LONDON, S.E. 18.

CREED

With the recent acquisition of the MURRAY PRINTING TELEGRAPH SYSTEM, and our most recent development, the CREED START-STOP SYSTEM, we are now able to offer our Customers the choice of three distinct TELEGRAPH SYSTEMS, namely :—

THE CREED HIGH-SPEED AUTOMATIC SYSTEM, the original Creed System, now well known and used throughout the world by leading GOVERNMENTS, CABLE COMPANIES and NEWSPAPERS.

THE CREED START-STOP SYSTEM, a direct printing telegraph system destined to be used extensively on short lines as between offices and works, for news distribution, etc., etc. The transmission is **"direct to"** line and reception, and printing effected **"direct from"** line instantaneously. BANKS, RAILWAYS, SHIP-

CREED & CO., LTD.,

Telegraph Engineers,

Telephone : Croydon 2121.

INSTRUMENTS

YARDS, COMMERCIAL and BUSINESS HOUSES are among the many who will be the users of this System in the near future.

THE MURRAY MULTIPLEX SYSTEM provides the user with the means of transmitting and receiving automatically from **four** to **ten** (according to the installation) distinct and separate messages over a single wire at the same time. It will therefore appeal to GOVERNMENT TELEGRAPH DEPARTMENTS and NEWSPAPERS in particular.

Apparatus for all three Systems is now manufactured on the well-known Creed System of **standardisation,** and intending customers may be assured that replace parts to the smallest detail are obtainable without difficulty.

We invite you to write for further particulars, or better still, arrange for a demonstration at our Works at Croydon.

TELEGRAPH WORKS
CROYDON, SURREY

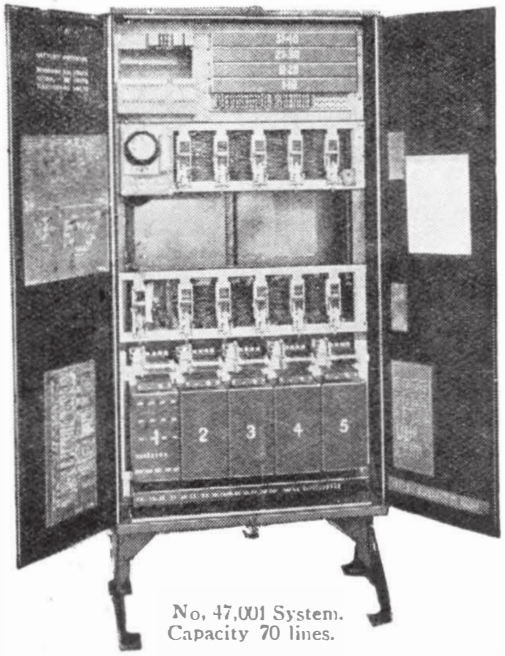
Telegrams : "Credo, Croydon."

Standard

FORMERLY

Western Electric

Automatic Telephone Systems



No. 47,001 System.
Capacity 70 lines.

STANDARD Automatic Private Branch Exchanges are essential to all business houses. They represent a time-saving factor of great value and increase the general efficiency of any organisation.

Here are some points for consideration :—

1. No operator is required, therefore the annual cost is negligible compared with a manually-operated switchboard.
2. The apparatus is ready for use day and night—or 8,760 hours per annum.
3. Absolute secrecy is secured on every call without any special manipulation of the Set on the part of the user.
4. High speed of operation. There is no waiting on the No. 47001 system, as the number is selected by the mechanism during the process of dialling.
5. The caller is instantly advised if the wanted line is engaged and (should he decide to hold the telephone for a minute or so) he is automatically connected as soon as the required line is free.
6. The caller is given confidence in the apparatus as he supervises the call and can hear the distant bell ringing.
7. The apparatus is simple to instal, being in standardised unit form.
8. It is economical to house because it may be fitted in a position which would be unsuitable for an operator.

Standard Telephones and Cables Limited

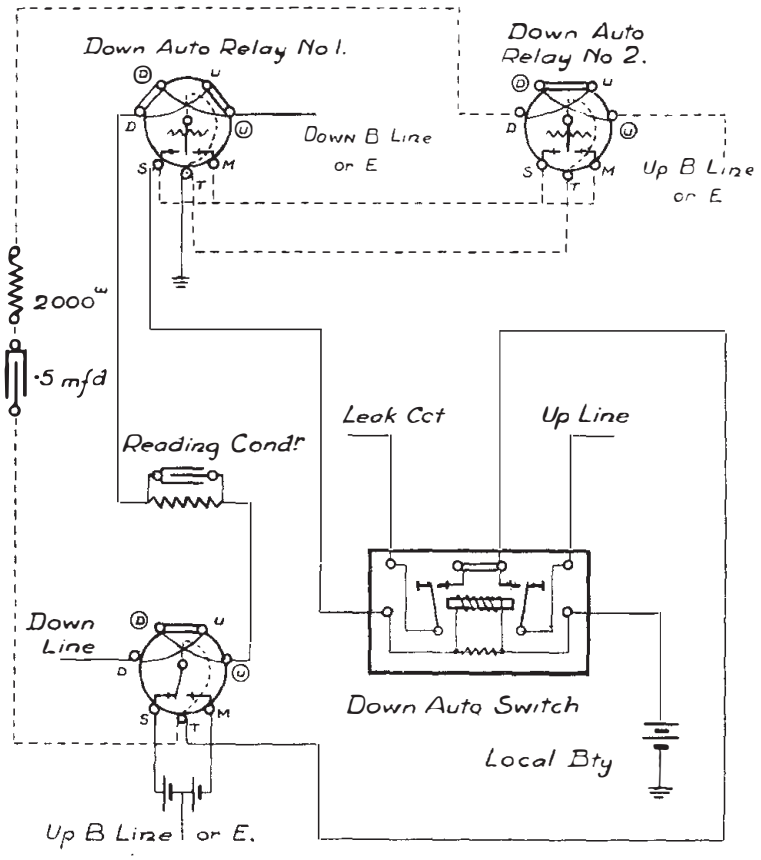
Connaught House, Aldwych, London, W.C.2.

'Phones: CENTRAL 7345 (10 lines). Works: HENDON, NORTH WOOLWICH and NEW SOUTHGATE. Branches: Glasgow, Leeds, Birmingham, Manchester, Cardiff, Liverpool, and Dublin.

THE
Post Office Electrical Engineers' Journal

SIMPLEX WORKING ON FAST SPEED REPEATERS.

On long aerial lines difficulty is experienced at times when owing to weather loss, etc., the received currents are too weak to actuate the Auto relay, although the transmitting relay may be



Circuit of Second Auto. Relay dotted.

functioning perfectly. This applies more especially to the period when reversals are being sent by the distant transmitter. Similar conditions obtain on long underground circuits which are being worked at or near the possible maximum speed.

The Auto relay can never be quite so sensitive as the Line relay owing to the presence of the controlling springs and the necessity for more open contacts, as the tongue must be capable of taking a central position where, when at rest, it touches neither the " marking " nor " spacing " contact.

By the addition of a second Auto relay, joined up as shown by the dotted connections on the diagram, it is possible to utilise the signal sent out by the line relay for the purpose of keeping the automatic switch closed whilst signals are passing.

This arrangement obviates the necessity for reducing the resistance of the reading condenser, as is sometimes done, in order to make the Auto relay function properly and will therefore assist in maintaining the normal speed of working.

E. LACK.

THE LONDON—GLASGOW TRUNK TELEPHONE CABLE AND ITS REPEATER STATIONS.

THE London-Derby No. 2 cable, which was accepted from the Contractors (Standard Telephones & Cables Limited) in December last, completes the London-Glasgow cable, the backbone of the trunk telephone cable network of Great Britain. The Derby-Glasgow section of the cable has already been in partial use for about a year, extension to London being provided by means of spare quads in the London-Derby No. 1 cable.

The object of this article is to describe particularly the London-Derby No. 2 cable, which represents the most modern practice in telephone cable manufacture and installation, and the Repeater Stations between London and Glasgow, all of which were equipped by the Standard Telephones & Cables Limited (formerly the Western Electric Co. Ltd.).

Fig. 1, which is reproduced from our Volume XVIII., page 261, shows the route of the main cable with its spurs and the location of the Repeater Stations.

As an indication of the density of traffic it may be noted that there are three telephone cables in the section London to Fenny Stratford, comprising a total number of 200 quads together with 28 telegraph quads, and between Fenny Stratford and Derby there are two cables, comprising a total of 202 quads including the telegraph quads previously mentioned, while the Derby repeater station is designed for an ultimate equipment of 1500 repeaters.

CABLE.

Of the three cables between London and Fenny Stratford, one is the old London-Birmingham cable which was described in this Journal, Volume VIII., page 206. The second is

the London-Manchester cable, which is a medium-medium loaded cable installed immediately after the War and worked exclusively on a 2-wire basis and also furnishes the telegraph quads previously mentioned, and runs from London to Manchester with repeaters at Fenny Stratford and Derby. The third is a new cable furnishing the long circuits going North of Derby on the Glasgow route. A cross-Section of this cable is shown in Fig. 2. This route runs from London to Glasgow with repeaters at London,

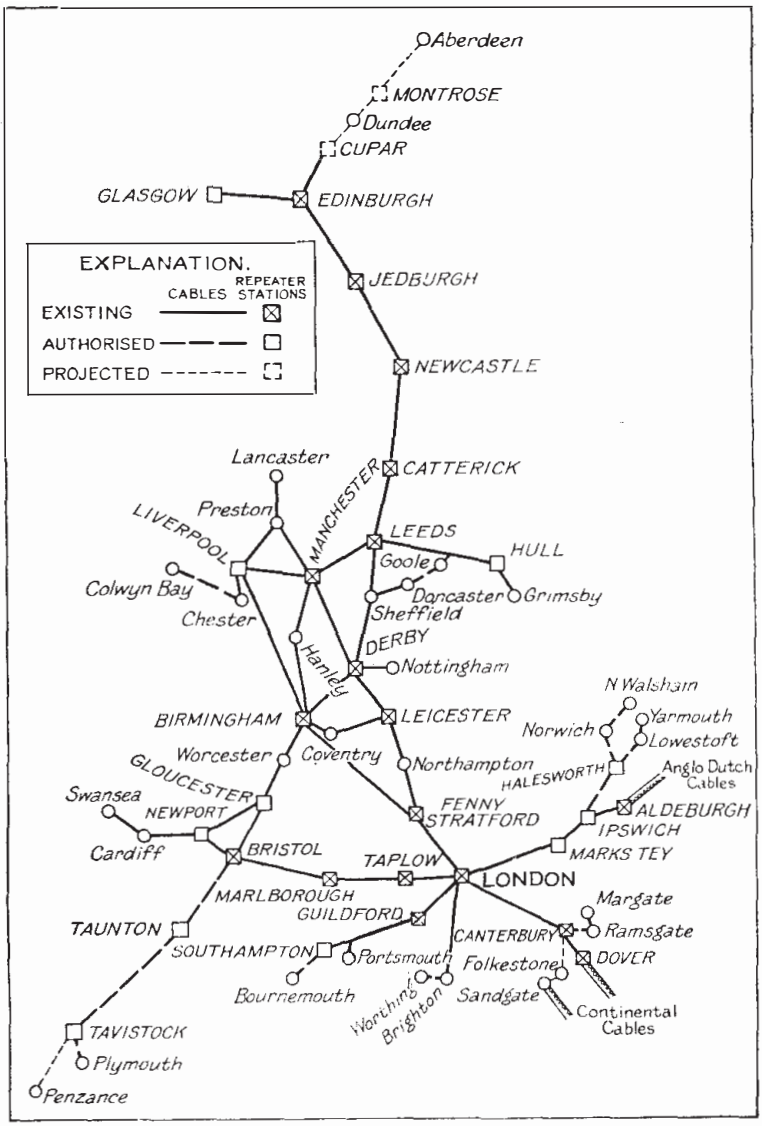


FIG. 1.—TELEPHONE REPEATER STATIONS—PLAN OF SYSTEMS.

Fenny Stratford, Derby, Leeds, Catterick, Newcastle, Jedburgh, Edinburgh and Glasgow. This cable is of particular interest as it shows the segregation of the 4-wire circuits in the Up and Down groups, while the 2-wire circuits form the centre of the cable. The 4-wire circuits are 20 lb. and are medium-heavy, half medium-

heavy and extra light loaded in accordance with their allocation to various points on the route, while the 2-wire circuits are 40 lb. medium-heavy loaded throughout.

The order for the London-Derby portion of this long cable together with its loading equipment was placed in November, 1924, and the cable was completed in December, 1925.

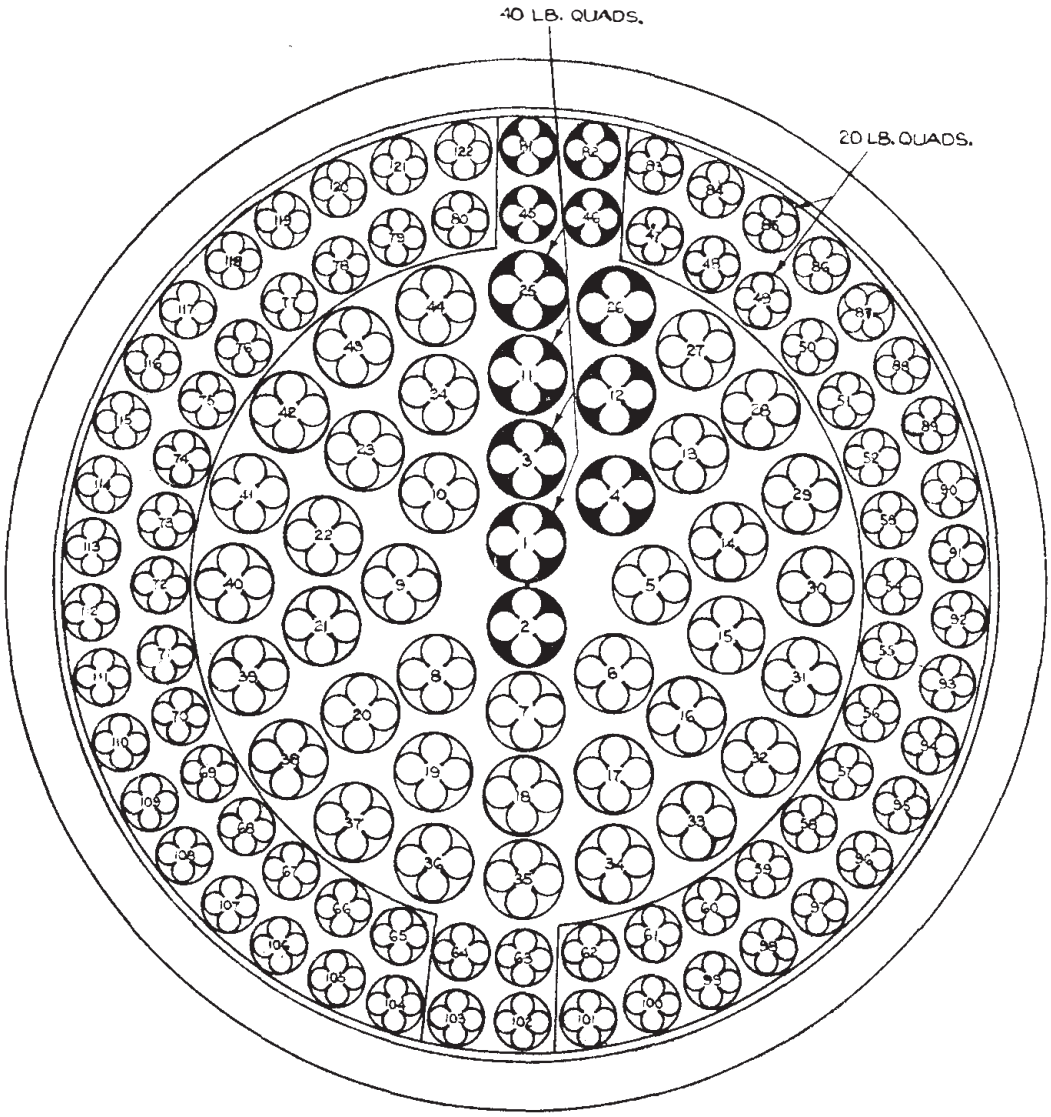


FIG. 2.—SECTION, LONDON-DERBY CABLE.

During this period nearly 130 miles of cable were pulled in, tested and jointed and over 450 loading coil cases were installed. The cable consists of 44 quads of 40 lbs. conductors and 78 quads of 20 lbs. conductors arranged as shown in Fig. 2. The loading is H-177-107, H-89-50 and H-44-25 (known as medium-heavy, half medium-heavy and extra light respectively, where H represents the loading coil spacing and equals 6000 ft., the first figure the

C.L.T.3. STANDARD TELEPHONES & CABLES LTD

L.S.N°

Type of Test

CAPACITY UNBALANCE DATA SHEET. ....BUFF.

Date

LONDON SIDE								CALCULATED RESULTANT		CHECK TEST			DERBY. SIDE			
QUAD N°	1/3 2/3	U V	PH to S S to S	JOINTING DIAGRAM	PH to S S to S	U V	QUAD N°	PH to S S to S	U V	PH to S S to S	U V	1/3 2/3	PH to S S to S	U V	1/3 2/3	QUAD N°
1			− 25 − 30 − 15		+ 15 + 50 + 35		26	+ 10 + 20 0					+ 25 − 5 − 5			1
2			− 30 − 20 + 15		+ 30 + 15 − 10		27	0 − 5 + 5					+ 5 − 45 + 15			2
3			− 25 + 45 + 5		− 5 + 30 − 15		20	− 10 + 15 0					+ 50 + 40 + 5			3
4			− 25 − 25 + 10		− 10 − 20 − 25		32	0 − 5 0					− 20 − 30 + 15			4
5			− 5 + 10 + 5		+ 5 + 10 + 10		9	0 0 − 5					− 30 − 10 − 25			5
6			+ 25 − 30 + 15		− 15 − 15 + 15		36	+ 10 − 15 0					− 5 − 15 − 25			6
7			− 15 − 5 + 25		+ 25 − 15 + 10		34	− 5 + 10 0					+ 5 0 − 25			7
8			+ 10 + 10 − 10		+ 15 + 10 + 10		31	− 5 0 0					+ 15 + 30 + 15			8
9			− 20 + 5 + 5		+ 10 + 10 + 25		29	+ 5 − 5 − 5					+ 5 + 10 + 10			9
0			+ 25 − 30 − 10		− 35 − 30 − 20		33	− 10 0 + 10					− 5 + 25 − 5			0
11			+ 30 + 25 − 25		− 20 − 30 + 15		4	+ 10 − 5 − 10					− 25 + 10 − 35			11
12			+ 20 + 10 − 10		+ 15 + 5 + 15		35	+ 5 + 5 + 5					− 60 + 5 + 10			12
13			+ 10 + 5 − 30		+ 15 + 10 + 25		28	− 5 − 5 − 5					+ 10 + 10 + 25			13
14			− 20 + 25 − 30		+ 35 − 15 + 30		30	+ 10 + 10 + 5					− 30 + 10 + 10			14
15			− 20 − 20 + 10		+ 5 − 45 + 15		2	− 5 + 25 + 5					+ 10 − 5 − 30			15
16			+ 25 − 25 + 5		+ 5 − 10 − 20		43	+ 5 − 15 0					− 5 − 20 − 25			16
17			− 45 − 30 − 10		+ 45 + 10 + 5		24	0 − 20 − 5					+ 20 + 13 0			17
18			− 40 + 10 − 5		+ 50 + 10 + 5		18	+ 10 + 20 0					+ 50 + 10 + 5			18
19			+ 20 + 5 + 25		− 25 − 15 − 25		38	− 5 − 10 0					+ 5 − 10 − 50			19
20			− 15 − 5 − 15		+ 25 + 10 + 15		40	+ 10 + 5 0					− 5 + 30 − 15			20

TESTER	LOCATION	REMARKS.
JOINTER	TEST POINT	
WEATHER	TO	
SET N°	AND	

FIG. 3.—TYPICAL JOINTING DIAGRAM.

side circuit coil inductance and the second figure the phantom circuit coil inductance). The following circuits are initially provided :—

102	circuits	40 lbs.	H-177-107	for	2-wire.
6	,,	40 ,,	H-44-25	,,	transatlantic work.
60	,,	20 ,,	H-177-107	,,	4-wire.
42	,,	,, ,,	H-89-54	,,	,,
6	,,	,, ,,	H-44-25	,,	,,

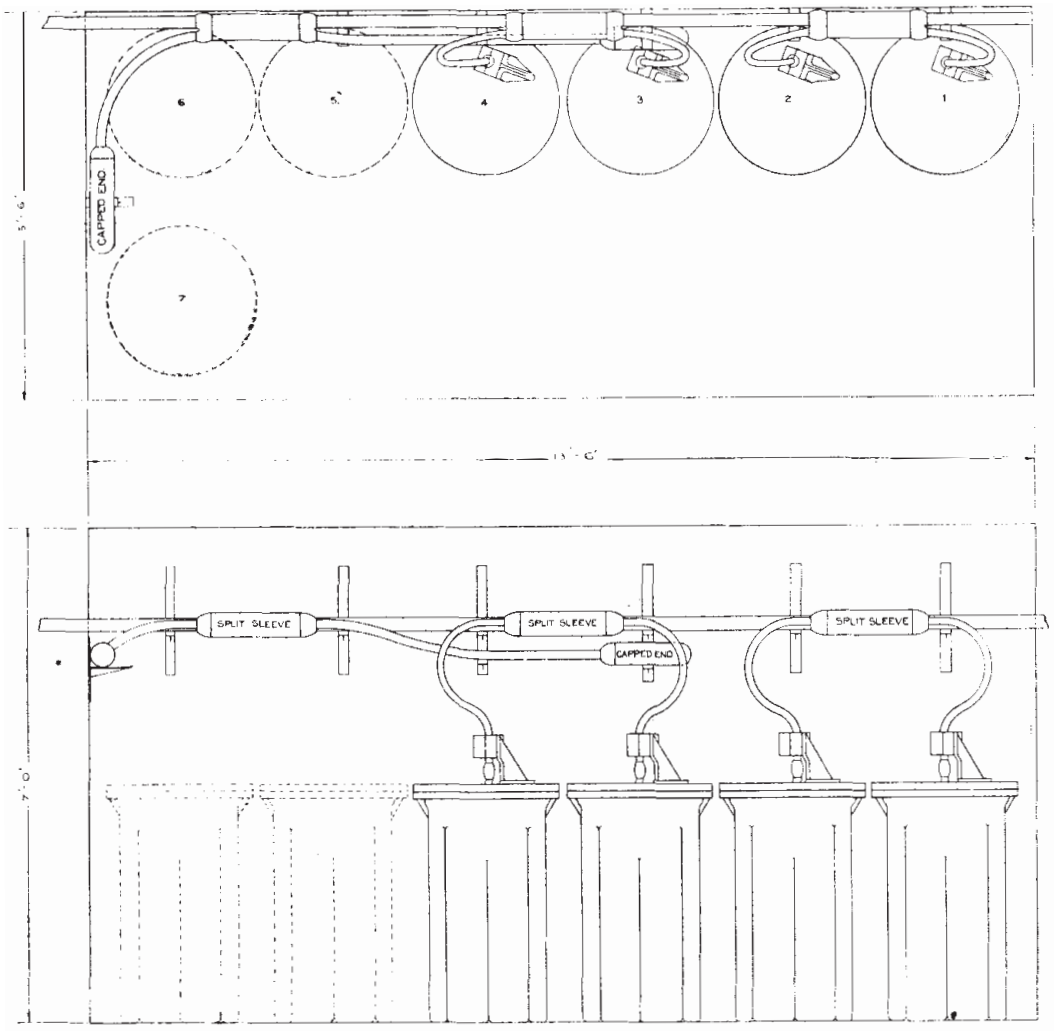


FIG. 4.—LAYOUT OF MANHOLE WITH SINGLE STUB CASES.

A typical jointing diagram for this cable is shown in Fig. **3**, which illustrates the method of jointing a cable by which the capacity unbalance is reduced by cross-splicing. There are usually three or seven such test splices made in each loading section.

Loading.—In connection with the loading of the new cable, of which a cross-section was shown in Fig. **2**, single stub loading coil cases have been used. This method of jointing loading coils

into cables has an advantage over the two-stub method generally used on previous cables as it makes the loading coil manhole lay-

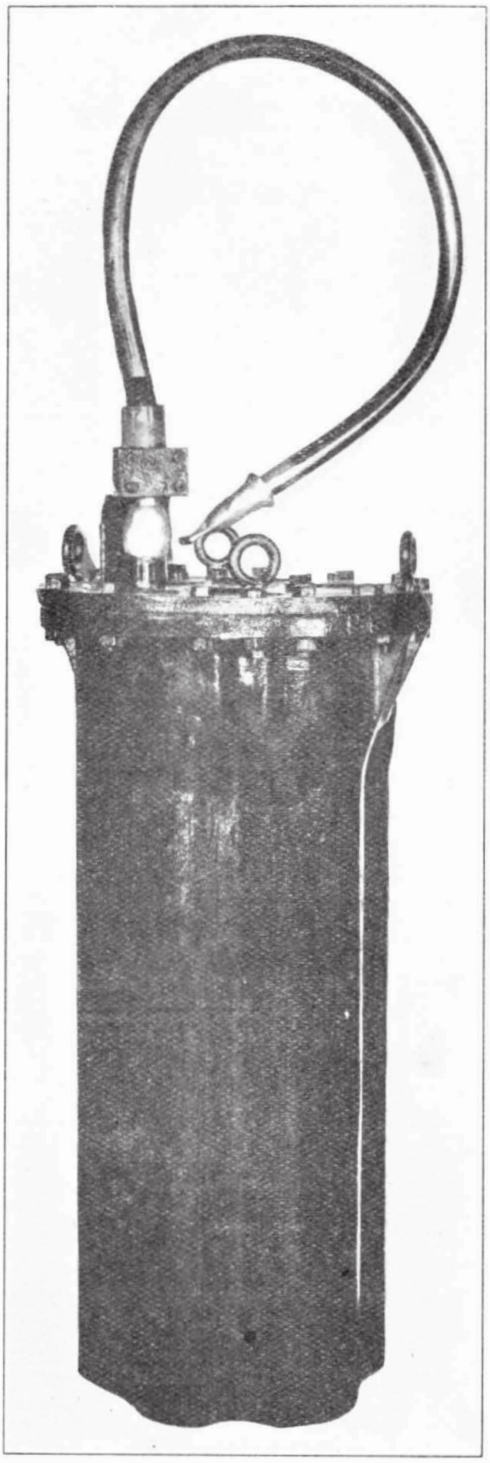


FIG. 5.—LOADING COIL CASE WITH SINGLE STUB.

out very much simpler. Fig. 4 shows the layout of loading coil cases in a manhole on this cable and illustrates the simplicity and

advantages of using the single stub construction. A photograph of one of the loading coil cases with a single stub, as used on this cable, is shown in Fig. 5.

Repeater Sections.—From the point of view of obtaining good transmission results from a repeatered system it is necessary that the constants such as impedance, attenuation, etc., of each repeater section shall be as uniform as possible, both as regards the values when plotted against frequency for any individual circuit as well as within each type of group. It is also essential that the cross-talk in the repeater section of cable shall be held within fairly close limits, since it can be proved that the repeater section cross-talk is the most important factor in the overall circuit cross-talk.

As explained above, it is important that the characteristics of the circuits shall remain as constant as possible, and for this purpose the following methods were adopted:—

Capacity Unbalance and Resistance Unbalance.—These unbalances were reduced as much as possible during the manufacture of cable lengths. Further reductions were obtained in the field by means of special test joints. Capacity unbalance was reduced generally at 3 test joints in each loading section, this number being increased to 7 at the ten loading sections adjacent to each repeater station.

Capacity Deviation.—The "regularity" to be maintained on the circuits, which was referred to earlier in this article, is closely connected with the deviations from the average mutual capacity. These capacity deviations are of two kinds, circuit deviations and section deviations. By the former is meant the deviations of the individual circuits of a group in a loading section from the average capacity of all the circuits in that group. By section deviation is meant the deviation of the average mutual capacity per loading section of a group of circuits from the average capacity for that group for all loading sections.

Circuit deviation was reduced both in the factory and in the field. In the latter case one test joint was made in each loading section, but this was confined to the ten loading sections adjacent to each repeater station.

The final tests on this cable were of two kinds, those on repeater sections and those on the repeatered system.

The following tests were made on the two repeater sections:—

(i) Loop Resistance.
(ii) Resistance Unbalance.
(iii) Insulation Resistance.
(iv) Singing Point.
(v) Impedance frequency.
(vi) Attenuation.
(vii) Cross-talk.

Tests Nos. (iv) (v) and (vii) were made from each end of each repeater section, the others being made from one end only. The results of these tests are summarised below:—

(i) *Loop Resistance.* This test was made chiefly as an assurance as to the uniformity of resistance of all similarly loaded circuits of the same gauge.

(ii) *Resistance Unbalance.* This test was made to measure the resistance unbalance between the wires of each pair. In no case was a resistance unbalance of more than 2 ohms found, the average unbalance being about 0.2 ohms.

(iii) *Insulation Resistance.* The insulation resistance was measured on all wires, and no value lower than 50,000 megohms per mile observed.

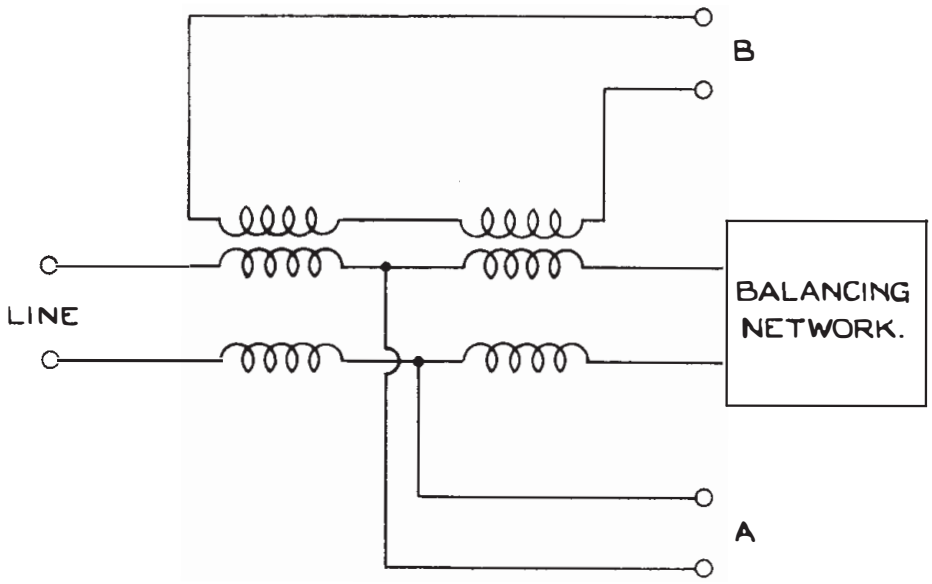


FIG. 6.—CIRCUIT OF UNBALANCE SET.

(iv) *Singing Point.* The singing points of all 2-wire circuits were measured from each end of each repeater section. The results are tabulated later.

Two distinct methods of measurement were adopted, one using a singing point test set and the other an impedance unbalance measuring set.

The singing point test set is virtually a portable 2-wire repeater and the results of the tests made with it are therefore a direct indication of the maximum gain which could be inserted in the line at the point at which the test is taken. As the maximum gain which it is usually desirable to obtain from a 2-wire repeater is of the order of 15 TU it will be seen from the results of the singing point test, that a very ample margin of safety exists on the circuits

of the London-Derby cable. This margin, however, has a directly beneficial effect on the quality of speech transmitted.

From the results obtained in this way typical circuits were selected for further analysis.

The other method of measuring singing points is based on the relation between singing point and the impedance unbalance between two circuits or a circuit and its balancing network.

Fig. **6** shows the essential part of the circuit by which singing points are measured when using the Impedance Unbalance Measuring Set. The coil shown in the figure is the so-called " hybrid " coil which is used in 2-wire repeaters to obtain duplex

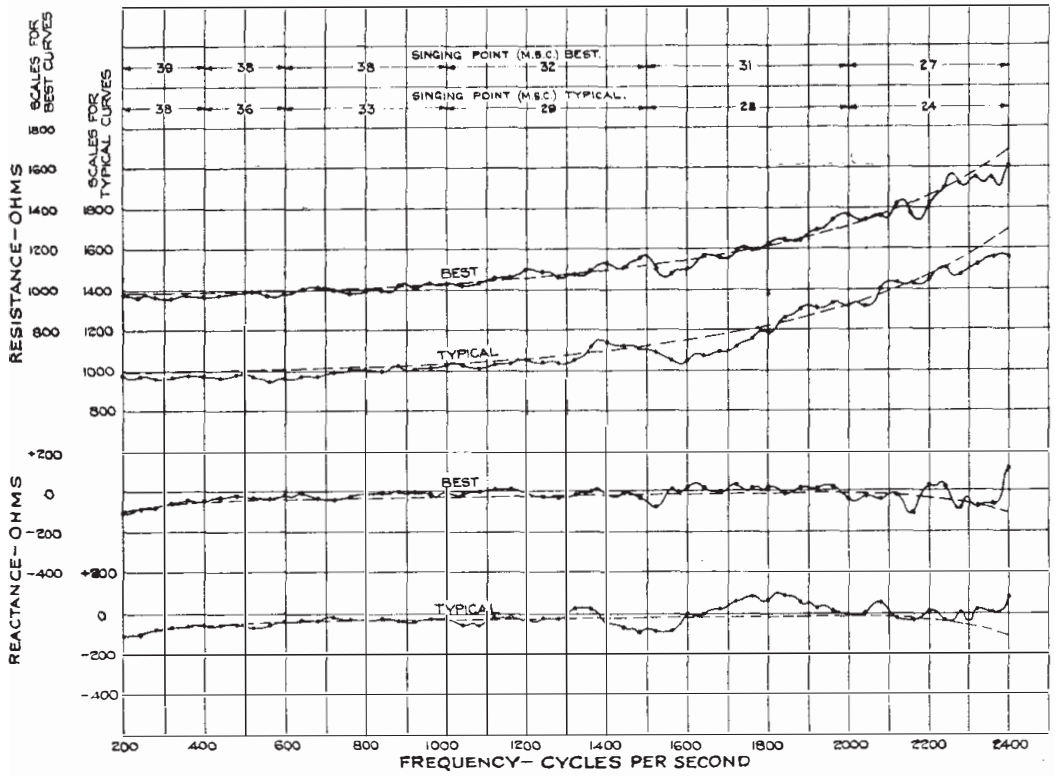


Fig. 7.—Impedance Curves H-177-107. Medium Heavy 40 lbs. Phantom Circuits.

operation. If the balance between line and network were perfect, the transmission loss between A and B would be infinite—*i.e.*, all current entering the circuit at A is divided between the line and network, no current passing across the windings to B. As soon, however, as there is any impedance unbalance between line and network some current does flow from A to B, the amount of this current depending on the magnitude of the impedance irregularity.

The Impedance Unbalance Measuring Set is designed to measure the transmission loss between A and B, and since both this loss and the singing point are dependent on the degree of

balance between line and network the set may be calibrated to read the singing point of line and network.

With this apparatus it is possible to measure the singing point of the line at any required frequency, whilst the singing point test set merely selects the frequency, within the efficient range of the repeater, at which the unbalance is greatest and the singing point consequently lowest.

Singing points were measured with this set at frequency intervals of 20 p.p.s. from 200-2400 p.p.s.

This frequency range was then divided up into bands and the lowest value of singing point recorded for each band.

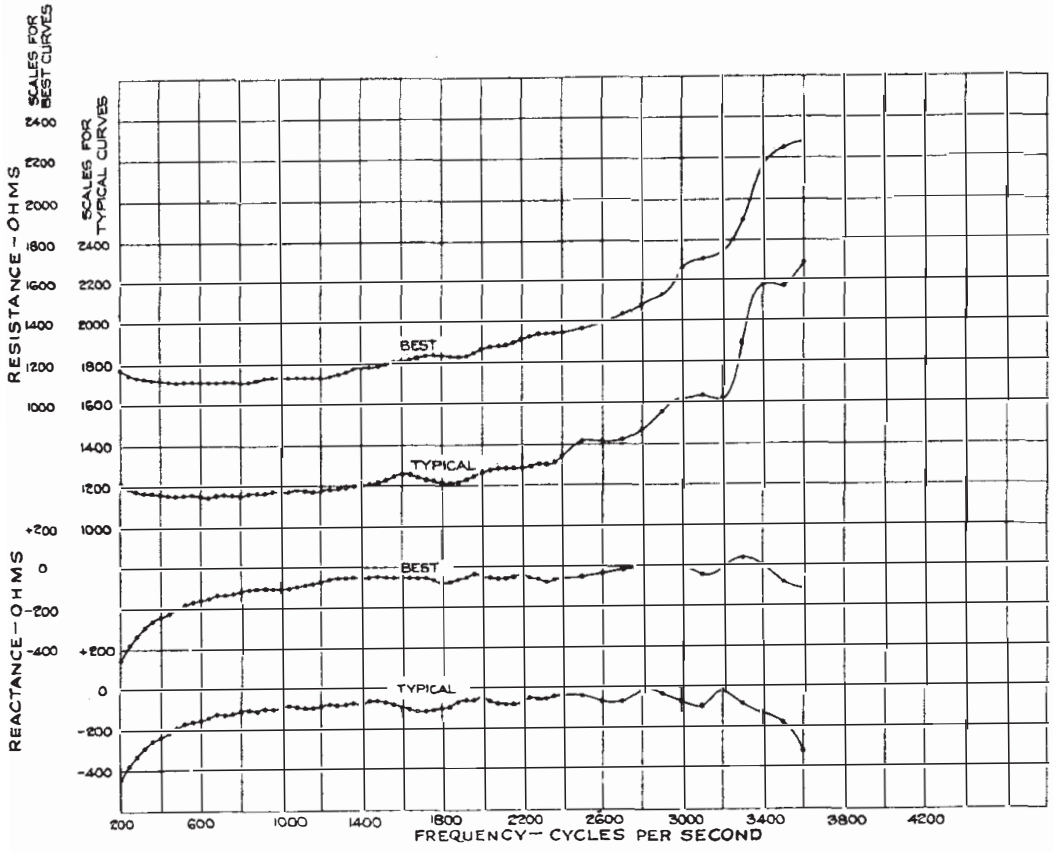


FIG. 8.—IMPEDANCE CURVES H-89-54. 20 LBS. SIDE CIRCUITS.

(v) *Impedance frequency.* Impedance frequency tests were made on about 10% of the loaded circuits in the cable, the 2-wire circuits being the same as those selected for the singing point tests made with the impedance unbalance set.

Typical curves are shown in Figs. **7**, **8** and **9**. Impedance frequency curves afford a ready means of ascertaining the degree of regularity obtained on the circuits. Ideally, of course, the impedance frequency curve for the line would be quite smooth, and in such a case a perfect balance would be possible between a

line and its balancing network, which would give an infinite value for the singing point, provided always that the repeater itself were perfectly balanced.

In practice, however, irregularities will always appear in the curve and since it is not practicably possible to construct a balancing network which would follow the irregular shape of the curve there will always be impedance unbalances between line and network at many points in the frequency range.

The singing point of the line will depend on the magnitude of these unbalances.

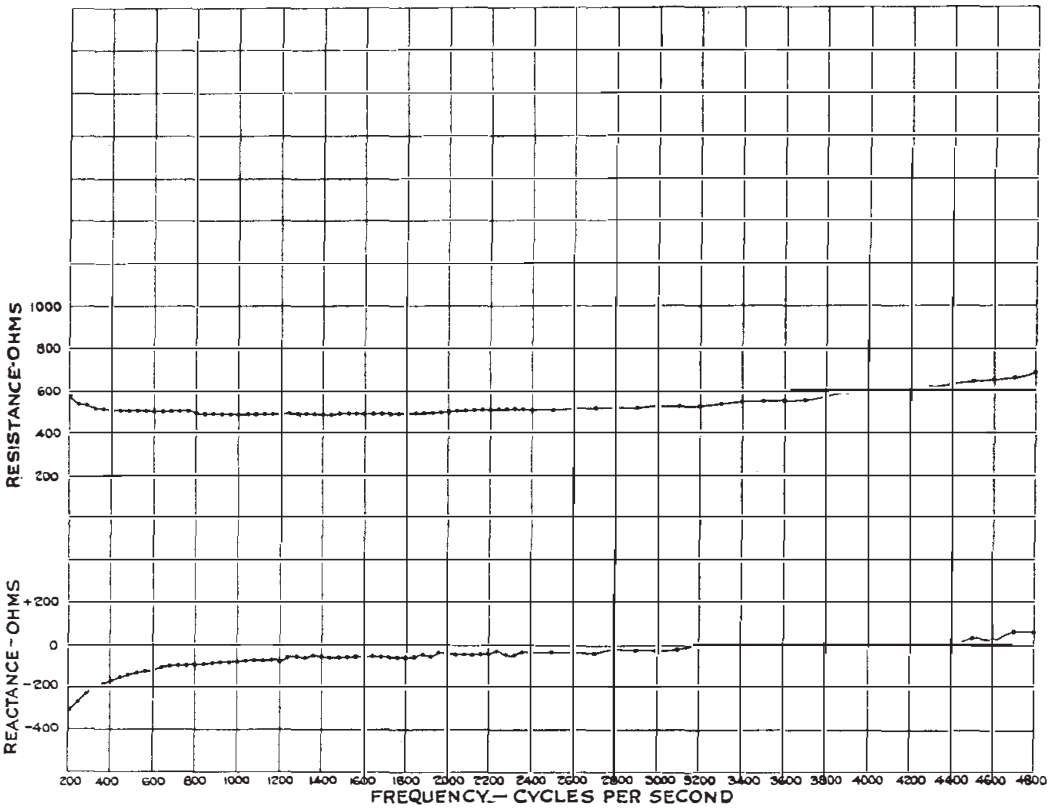


FIG. 9.—IMPEDANCE CURVES H-44-25. 20 LBS. PHANTOM CIRCUIT.

One point is of considerable interest in this connection and is illustrated by Fig. 7, which shows the impedance frequency curve of one of the 2-wire circuits. On the same curve is plotted the impedance frequency curve of the standard network with building out condenser which is employed at the repeater stations. With cables constructed, installed and tested by the method employed on this cable the networks can be designed from the prime constants of the cable and one network will furnish excellent results with all circuits. Details of these networks and a multi-unit condenser which is used as a building-out section will be dealt with under Repeater Equipment.

SINGING POINTS (TU).

Repeater Section.	Tested from	Circuit		Singing Point Measured with Impedance Unbalance Set. Frequency Bands						S.P. Measured with S.P. Test Set.
				200-400	400-600	600-1000	1000-1500	1500-2000	2000-2400	
London	London	Side	Best	37	38	36	35	28	22	32
,,		,,	Worst	37	38	33	26	24	23	24
,,	,,	Phant.	Best	34	33	32	29	28	25	30
,,	,,	,,	Worst	36	36	32	26	24	24	22
,,	Fenny Stratford	Side	Best	38	38	35	30	32	24	32
,,		,,	Worst	38	38	30	24	24	26	26
,,	,,	Phant.	Best	37	36	36	30	29	26	32
,,	,,	,,	Worst	38	34	30	29	25	25	26
Derby	Fenny Stratford	Side	Best	37	36	35	34	32	28	32
,,	,,	,,	Worst	37	35	34	34	27	27	29
,,	,,	Phant.	Best	38	34	35	33	24	23	21
,,	,,	,,	Worst	38	31	32	28	24	25	24
,,	Derby	Side	Best	35	38	31	32	29	26	32
,,	,,	,,	Worst	34	35	32	26	28	25	27
,,	,,	Phant.	Best	36	37	37	36	28	21	32
,,	,,	,,	Worst	35	32	32	30	30	22	25

N.B.—The above figures are the lowest values of singing point recorded in the various frequency bands.

(vi) *Attenuation.* Measurements of attenuation were made at various frequencies, all loaded circuits being measured at 800 and at 2000 p.p.s., and a number of circuits, typical of each circuit group, over a frequency range.

The average attenuation, corrected to 50°F., for each type of circuit at 800 and 2000 p.p.s. is given in the following table:—

Attenuation (β per mile at 50° F.).

Type of Circuit.		800 c.p.s.	2000 c.p.s.
40 lb. H-177-107	Side	.0177	.0230
	Phantom	.0145	.0194
20 lb. H-177-107	Side	.0306	.0354
	Phantom	.0249	.0292
20 lb. H-89-54	Side	.0398	.0416
	Phantom	.0320	.0339
40 lb. H-44-25	Side	.0288	.0301
	Phantom	.0238	.0253
20 lb. H-44-25	Side	.0537	.0553
	Phantom	.0451	.0468

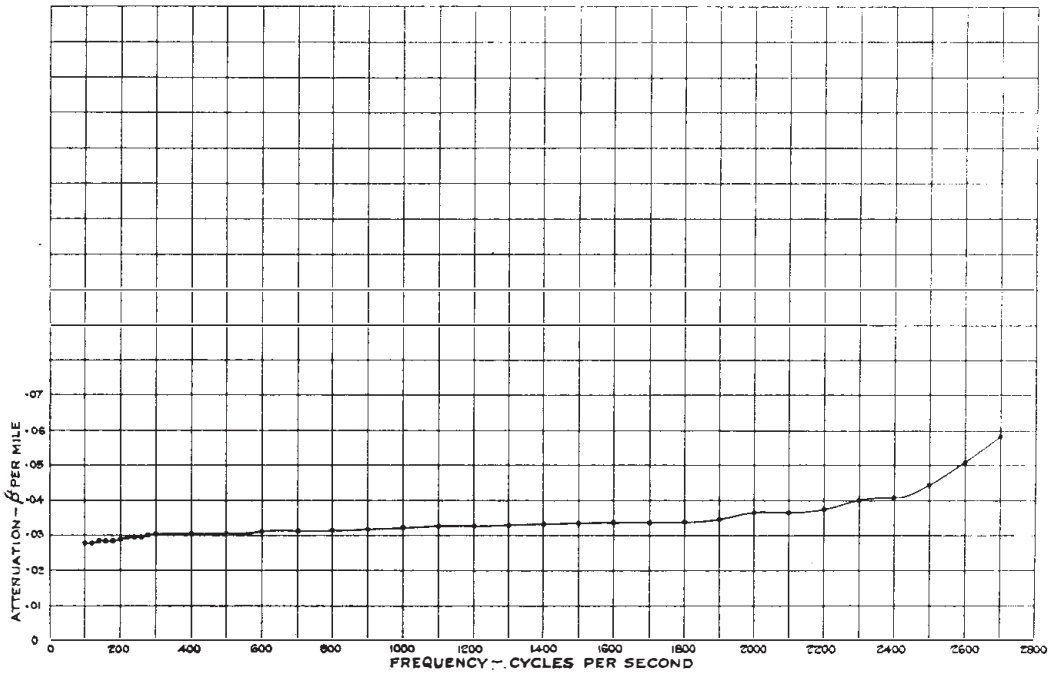


FIG. **10**.—ATTENUATION VS. FREQUENCY CURVE H-177-107. 20 LBS. SIDE CIRCUIT. MEASURING CURRENT 0.5 M.A.

In Fig. **10** is shown a typical attenuation frequency curve.

(vii) *Cross-talk.* Cross-talk measurements were made on all loaded circuits, using as testing current a complex tone which gives results very close to those which would be obtained in a speech test.

Near End cross-talk was measured on all 2-wire circuits. In these tests the measuring apparatus and the source of tone were always at the same end of the circuit.

Far End cross-talk was measured on the 4-wire circuits, tone being placed at one end of the circuit and the measuring apparatus at the far end.

All cross-talk results given in this article have been corrected in the case of phantom to side cross-talk on the basis of the phantom and side circuit impedances, and in the case of Far End cross-talk on the basis of the equivalent of the circuit over which the testing tone is sent.

The results are tabulated below :—

Near End Cross-talk (Cross-talk Units).

	Phantom-side.		Side-side.		Phantom-Phantom.	
	Ave.	Max.	Ave.	Max.	Ave.	Max.
40 lb. H-177-107	185	320	105	160	105	250

Far End Cross-talk (Cross-talk Units).

	Phantom-side.		Side-side.		Phantom-Phantom.	
	Ave.	Max.	Ave.	Max.	Ave.	Max.
London Repeater Section. 46.4 *miles.*						
20 lb. H-177-107	130	295	55	110	45	115
20 lb. H-89-54	90	190	25	60	25	45
20 lb. H-44-25	75	120	15	15	—	—
40 lb. H-44-25	180	250	65	75	—	—
Derby Repeater Section. 81.5 *miles.*						
20 lb. H-177-107	85	115	15	30	10	25
20 lb. H-89-54	60	85	5	5	5	5
20 lb. H-44-25	20	30	5	5	—	—
40 lb. H-44-25	155	175	130	145	—	—

Overall Tests.—The final series of tests made were system tests over repeatered circuits. The cable was completely installed before the repeaters were in operation and temporary repeater equipment was installed in order to enable overall tests to be made.

This temporary equipment was installed at London, Fenny Stratford and Derby in such a way as to allow both 2- and 4-wire repeaters to be inserted in any required cable circuits, which would then be set up from London to Derby and back again to London. Fig. **11** shows the arrangement of the repeaters on these circuits, from which it will be seen that both ends of the circuits were available in London.

The following tests were made on these 250 mile circuits :—

(i) Overall transmission equivalent.

(ii) Cross-talk.

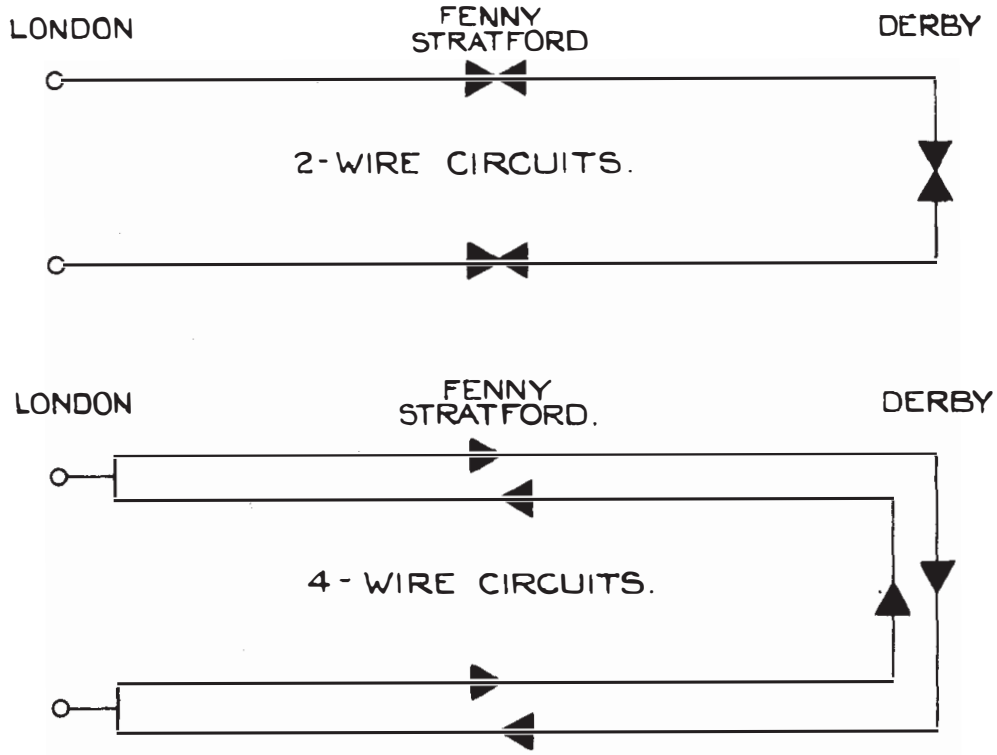


FIG. 11.—OVERALL TESTS : ARRANGEMENTS ON REPEATERS.

(i) Here again, all circuits were measured at 800 and 2000 p.p.s., the results of the tests being given below :—

800 and 2000 c.p.s. tests.

2-wire. Average overall equivalents in S.M. (1 *S.M.* = βl = 0.109).

	800 p.p.s.	2000 p.p.s.
Side	10.0	21.0
Phantom	9.0	20.0

4-wire. Average overall equivalents in S.M.

H-177-107	800 p.p.s.	2000 p.p.s.
Side	8.0	10.0
Phantom	6.0	7.0

H-80-54	800 p.p.s.	2000 p.p.s.
Side	13.5	15.0
Phantom	9.0	10.0

In the case of the half medium heavy circuit the above figures are somewhat high, due to the conditions of test. Under actual working conditions terminal repeaters will be used at London on the circuits, resulting in lower overall equivalents.

(ii) Cross-talk was measured through all the terminating equipment and the following results obtained:—

Overall Cross-talk (Cross-talk Units).

	Near End Cross-talk. 40 lb. H-177-107.		*Far End Cross-talk.* 20 lb. H-177-107.		20 lb. H-89-54.	
	Ph-S.	S-S.	Ph-S.	S-S.	Ph-S.	S-S.
Avg.	283	163	510	272	300	128
Max.	400	200	836	418	485	165

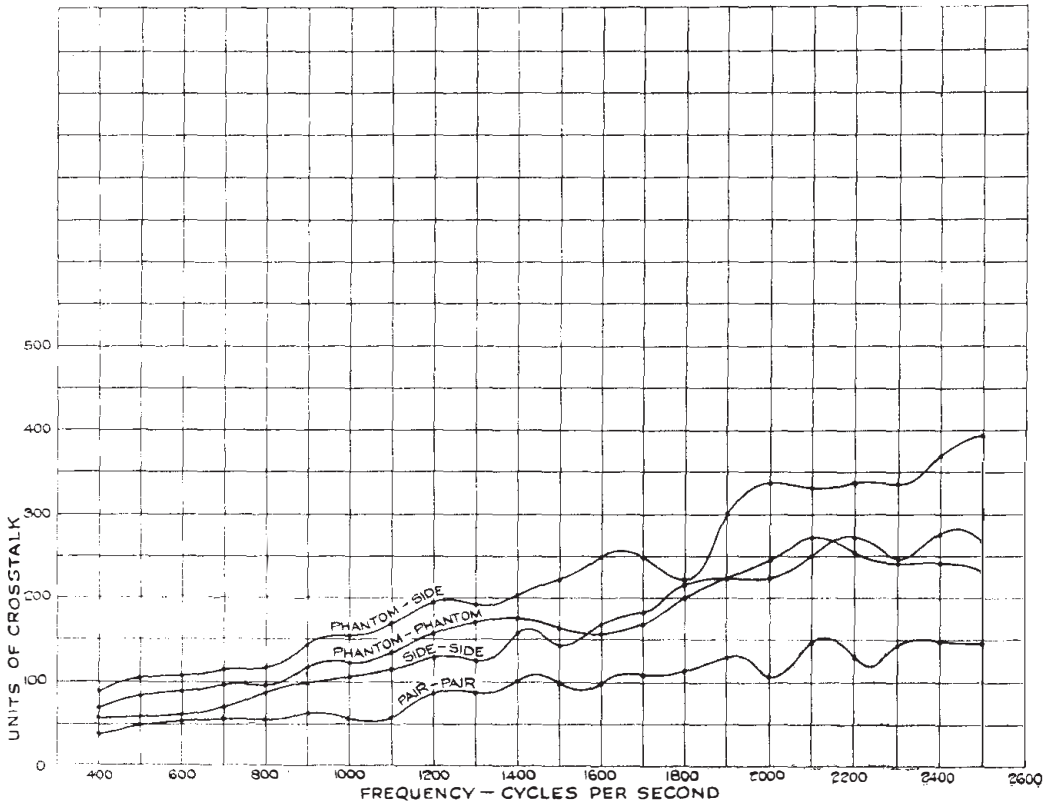


FIG. 12.—AVERAGE CROSS-TALK CURVES.

Particular attention should be paid to the cross-talk frequency curve shown in Fig. **12**, which gives the average figures obtained on the medium-heavy 40-lb. circuits for Phantom-Side, Side-Side, Phantom-Phantom and Pair-Pair, where the pairs are located in different quads.

REPEATER STATION EQUIPMENT.

To give a general picture of the apparatus, power plant, etc., used in the repeater stations on the North-East route, Fig. **13** shows a floor plan of the Derby repeater station. This floor plan does not cover the final station, which will cater for 1500 repeaters, as previously stated, but only with the repeaters installed up to the present time.

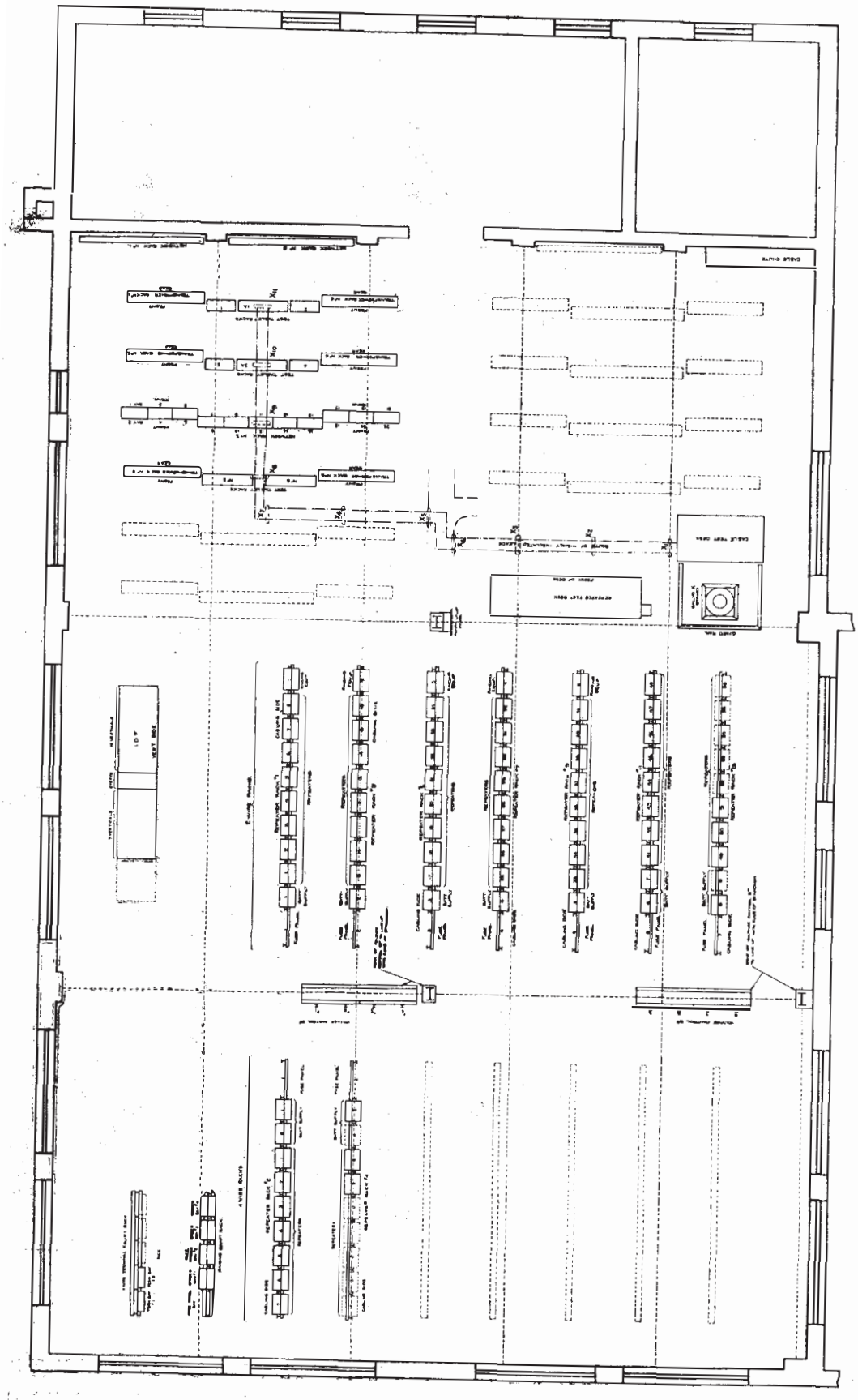
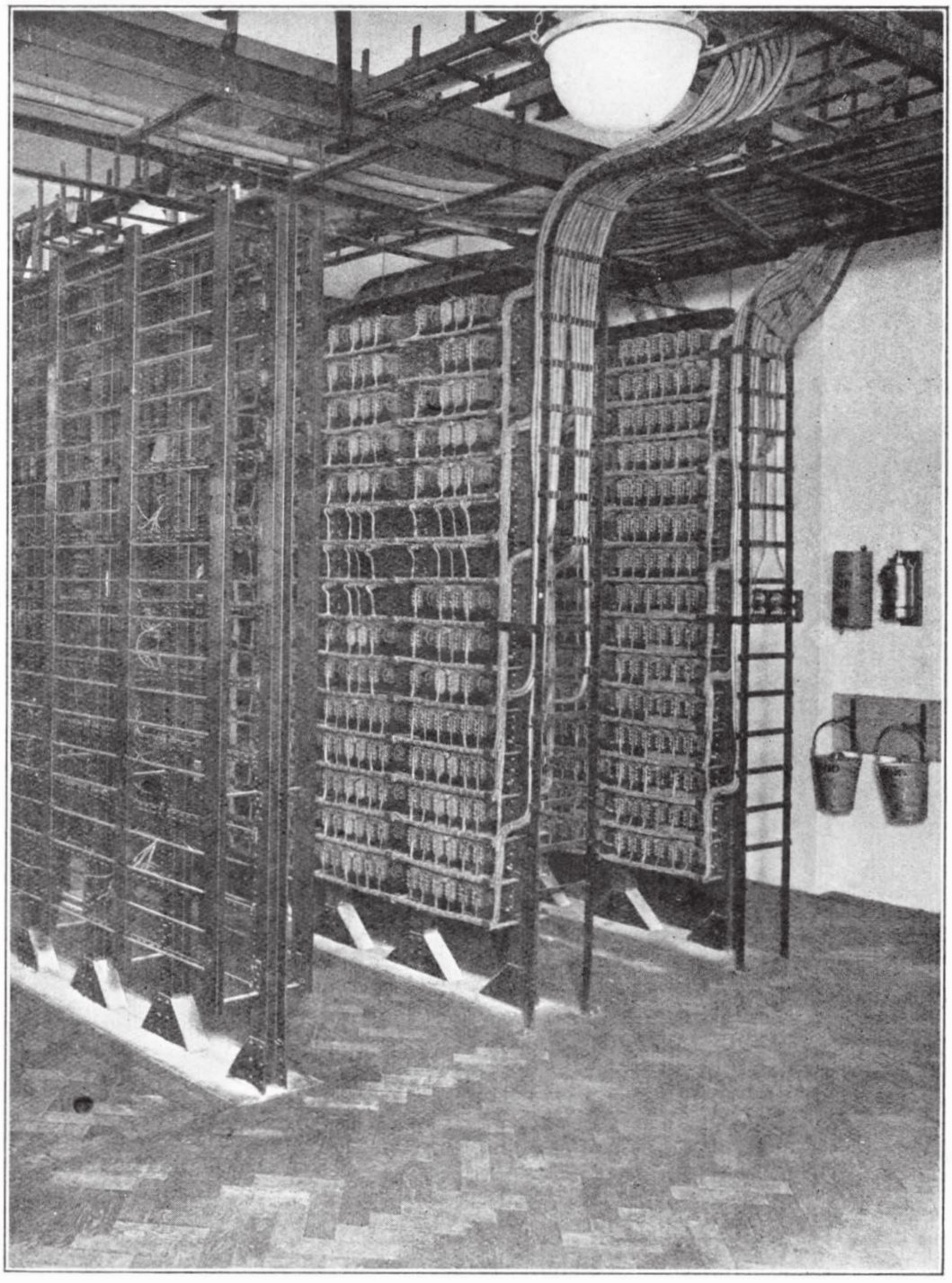


FIG. 13.—FLOOR PLAN, DERBY REPEATER STATION. (S.T. AND C. LTD. DRAWING, L 32669).

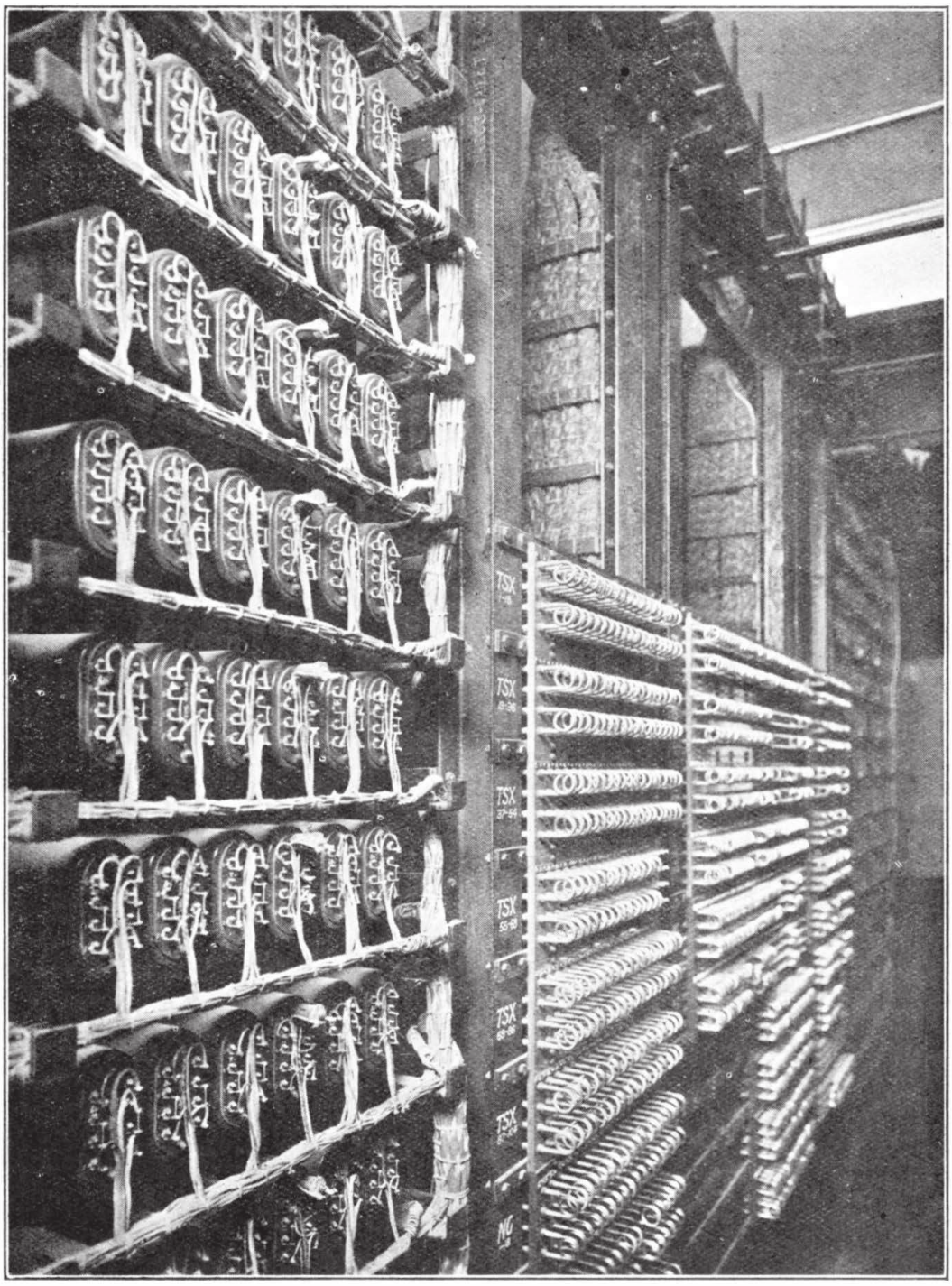
A series of photographs is given illustrating the power board, etc., at the Leeds repeater station; repeater bays, coil racks and test units at the Derby repeater station, and individual photo-



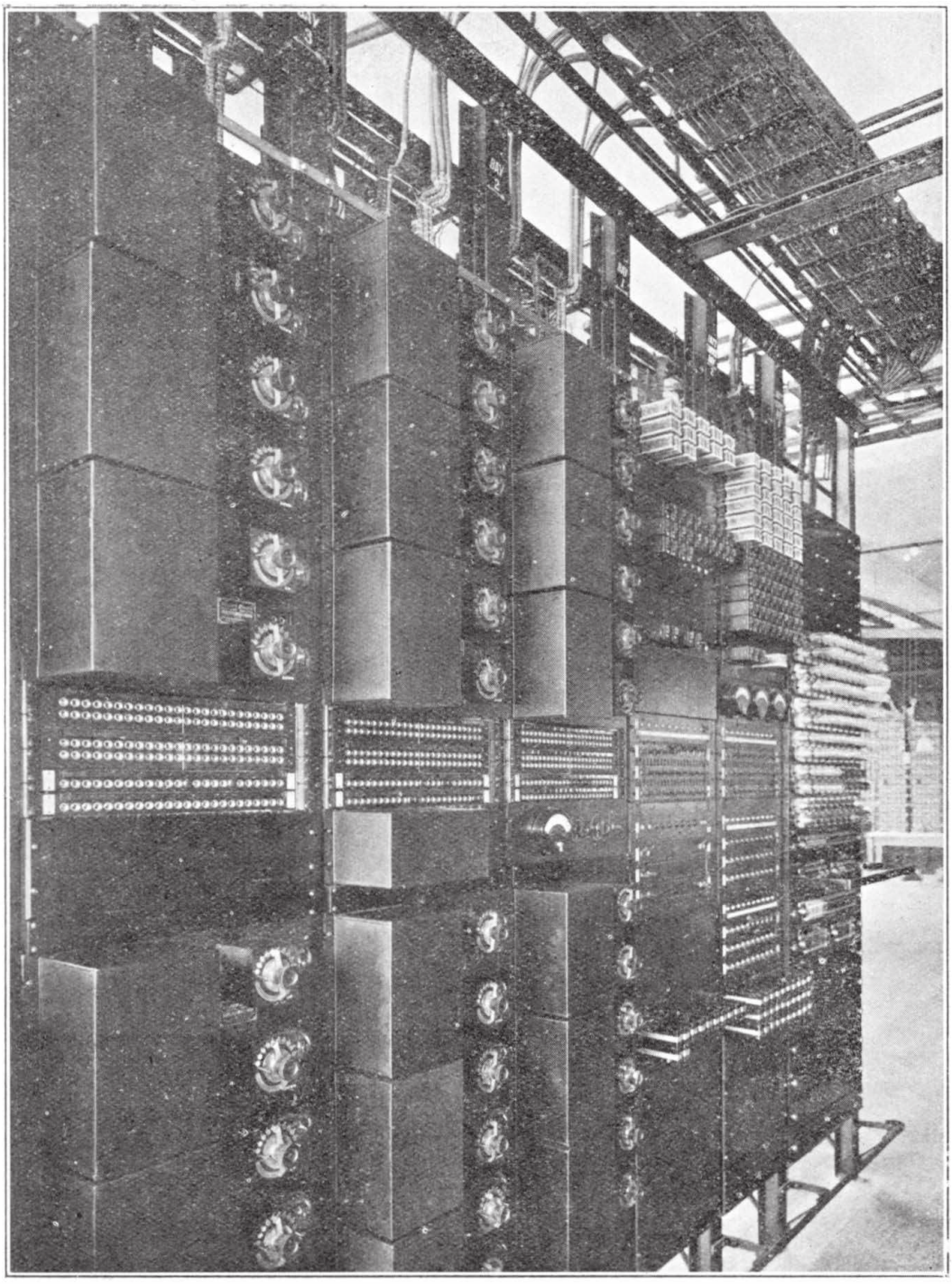
TEST TABLET AND TRANSFORMER RACKS. GENERAL VIEW.

graphs of the repeater units, both 2-wire and 4-wire. It is thought that the photographs are sufficiently self-explanatory not to need

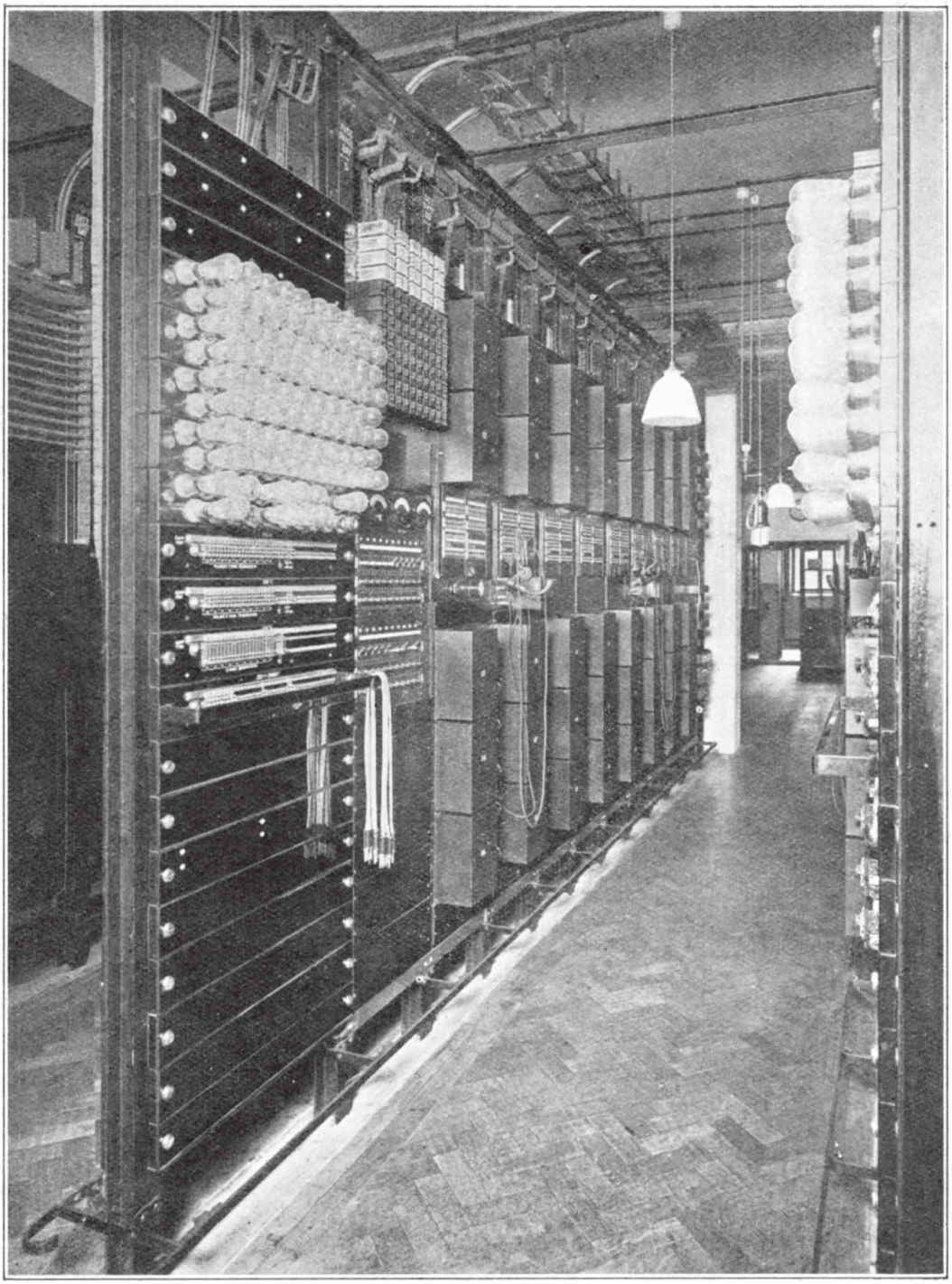
any description and that there is more interest in a description of the circuits involved on the whole system than on the equipment.



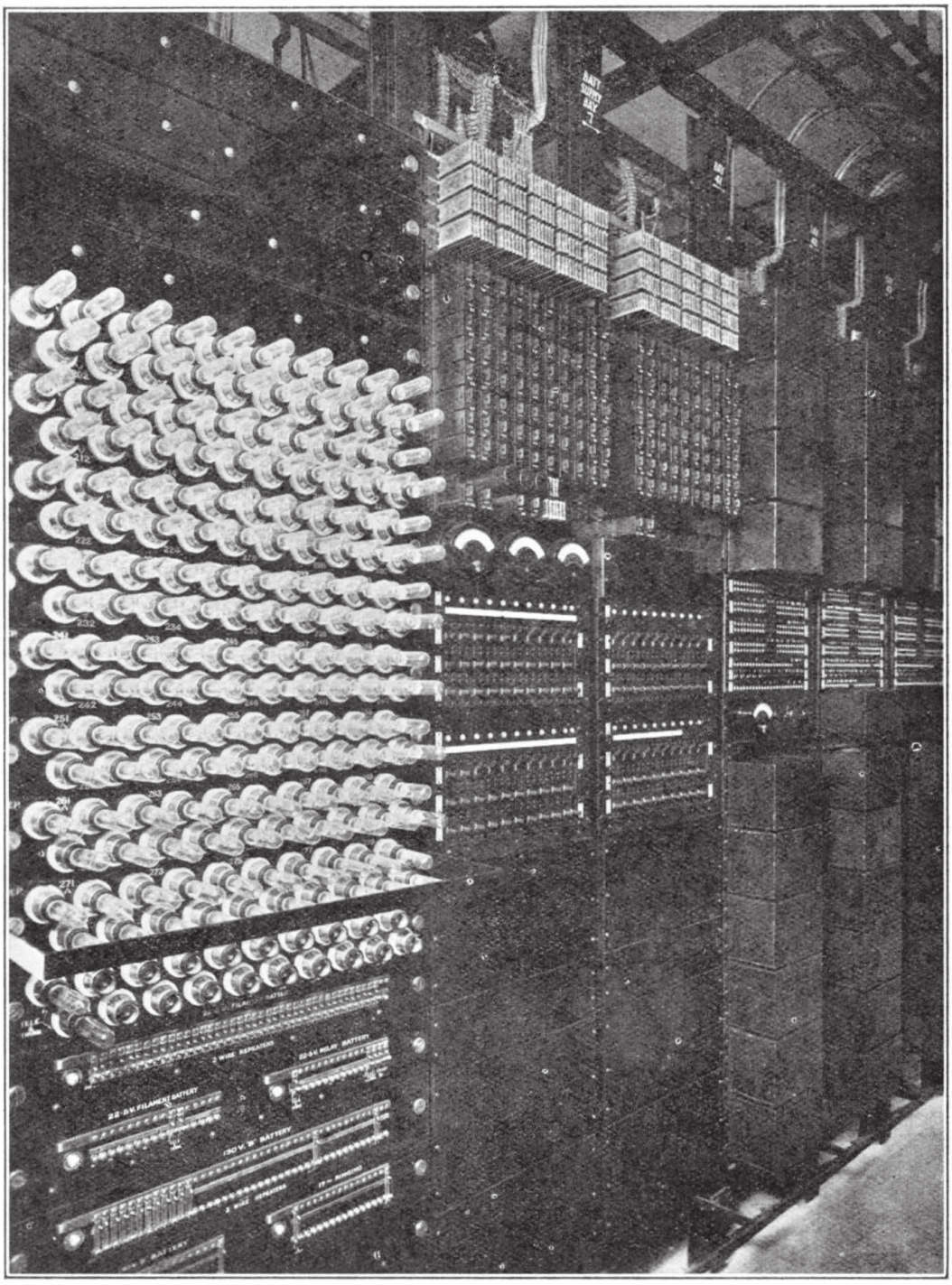
Test Tablets and Transformers.



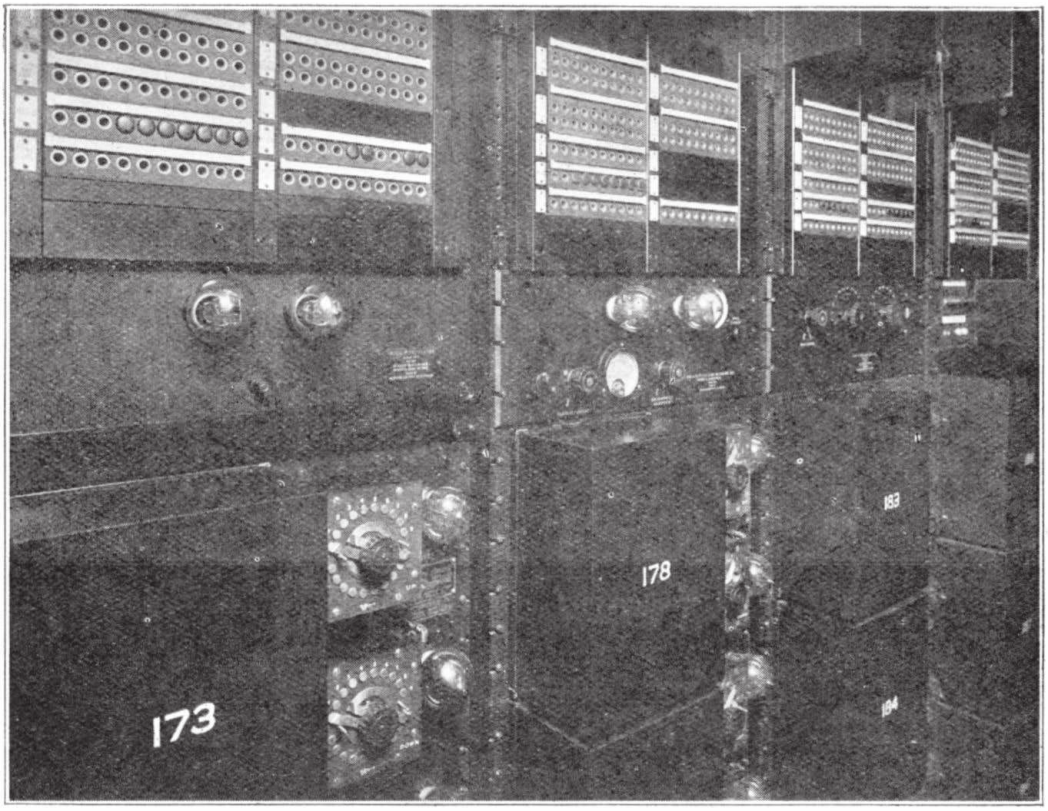
4-Wire Repeater Rack.



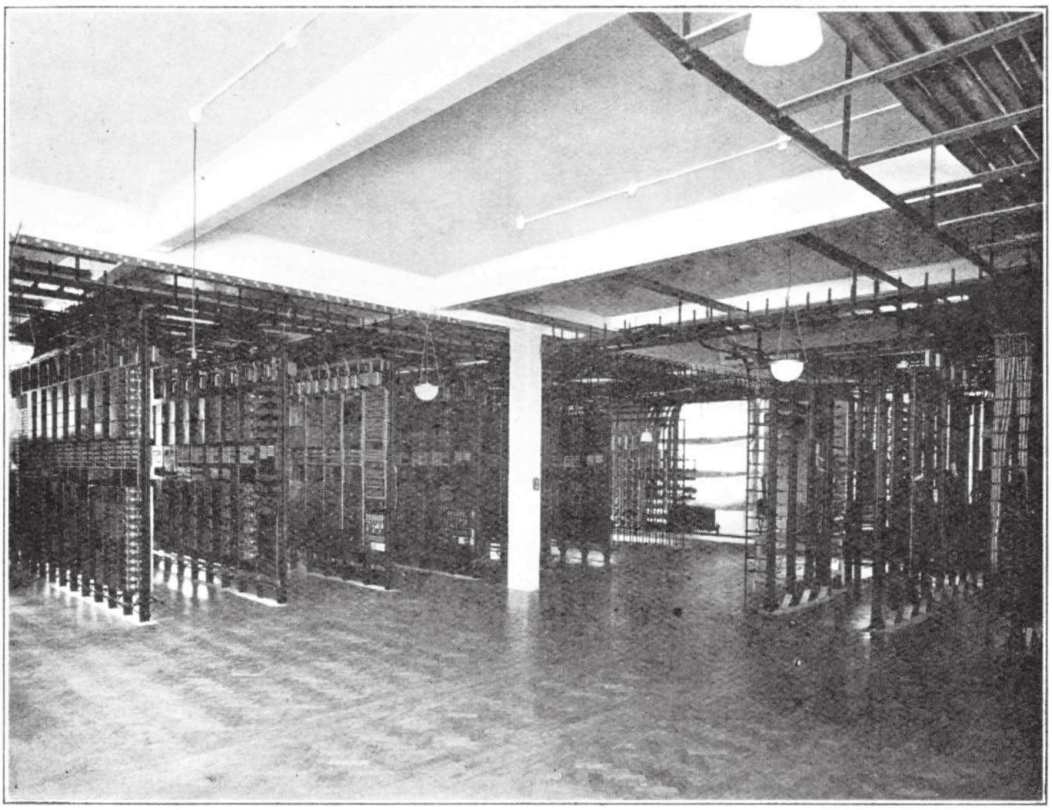
2-Wire Repeater Rack. Repeaters and Low-Frequency Signalling Apparatus.



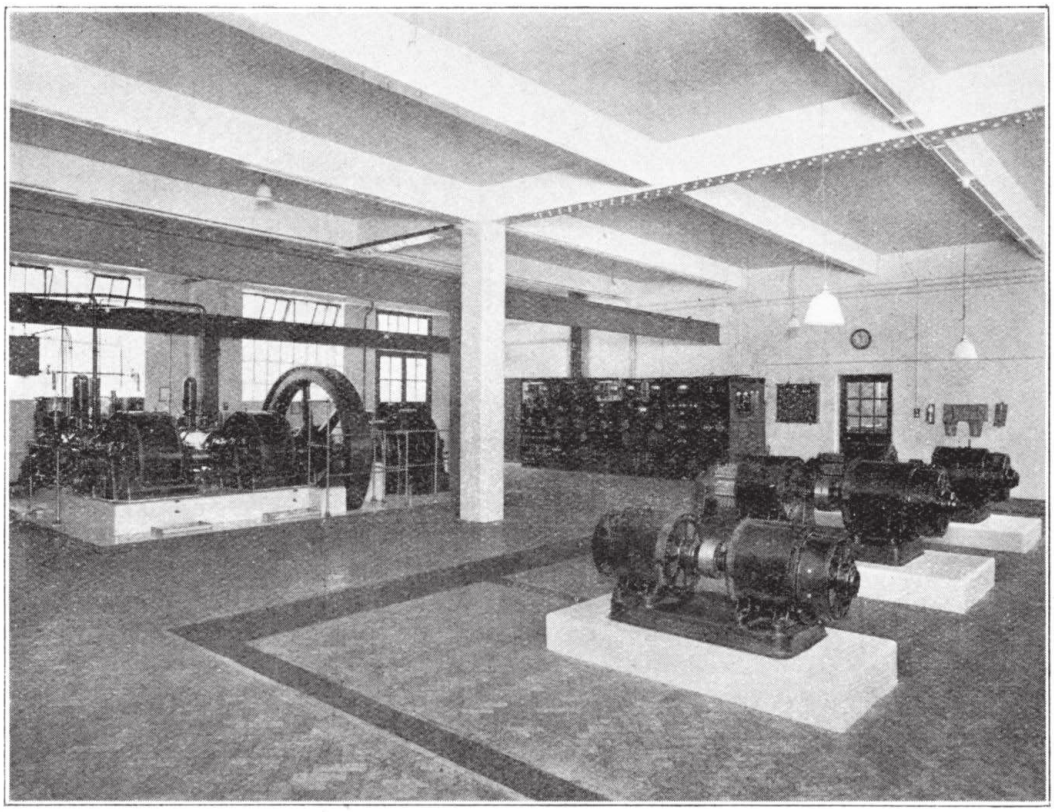
2-Wire Repeaters and Battery Supply Apparatus with Voice Frequency Signalling.



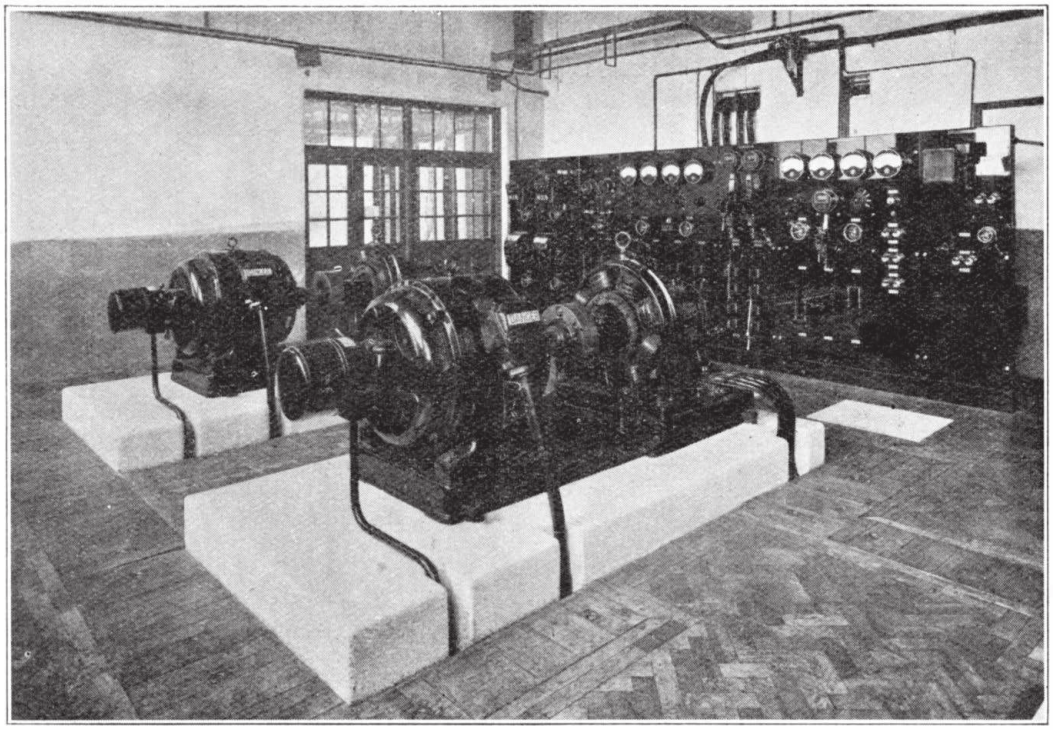
GAIN MEASURING INSTRUMENTS.



GENERAL VIEW. REPEATER APPARATUS ROOM, DERBY.



GENERAL VIEW. POWER ROOM, DERBY.



FILAMENT BATTERY CHARGING SETS AND POWER BOARD, LEEDS.

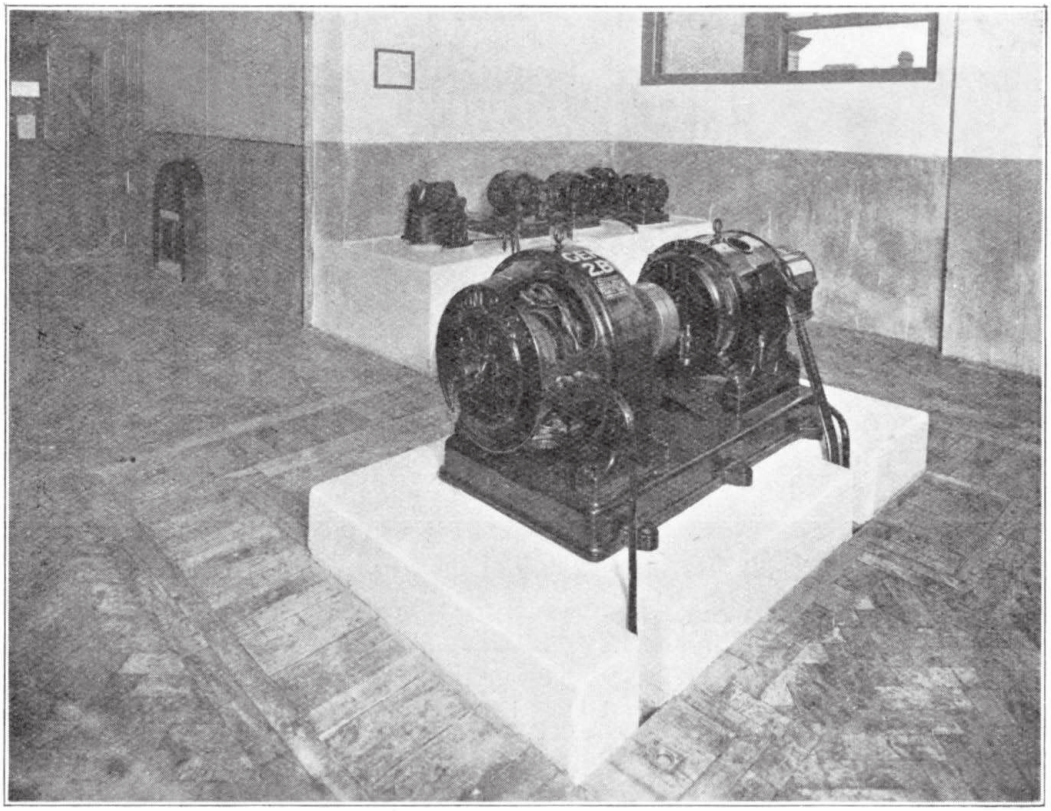
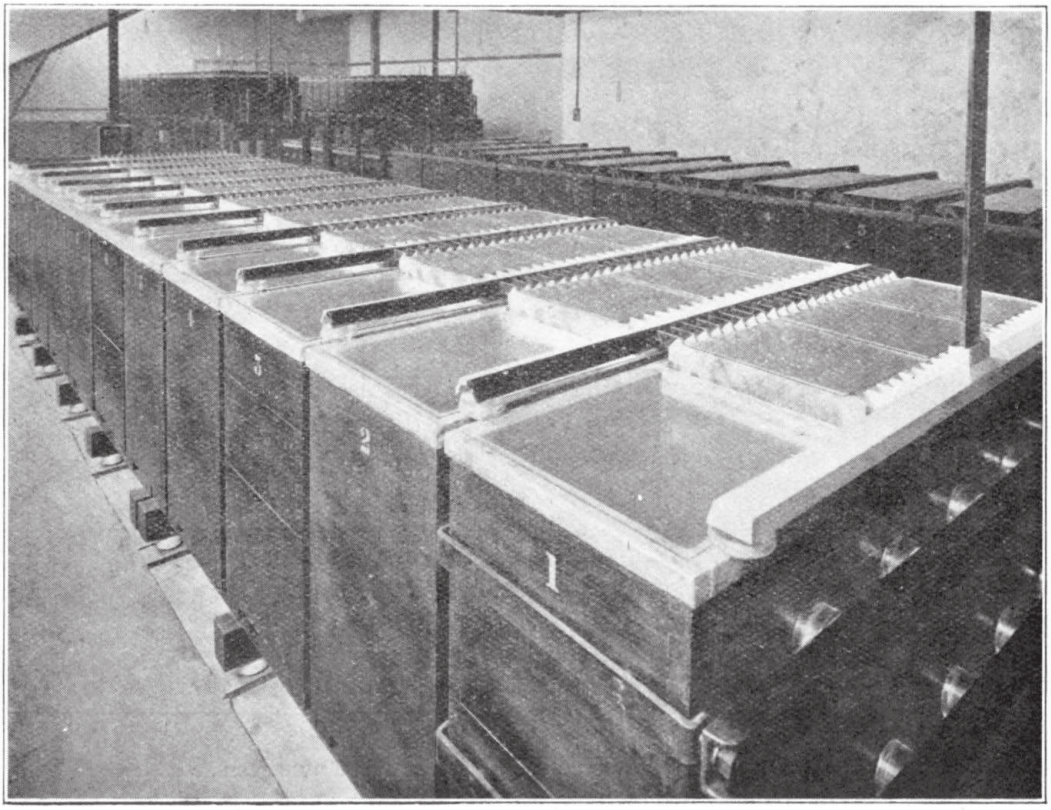
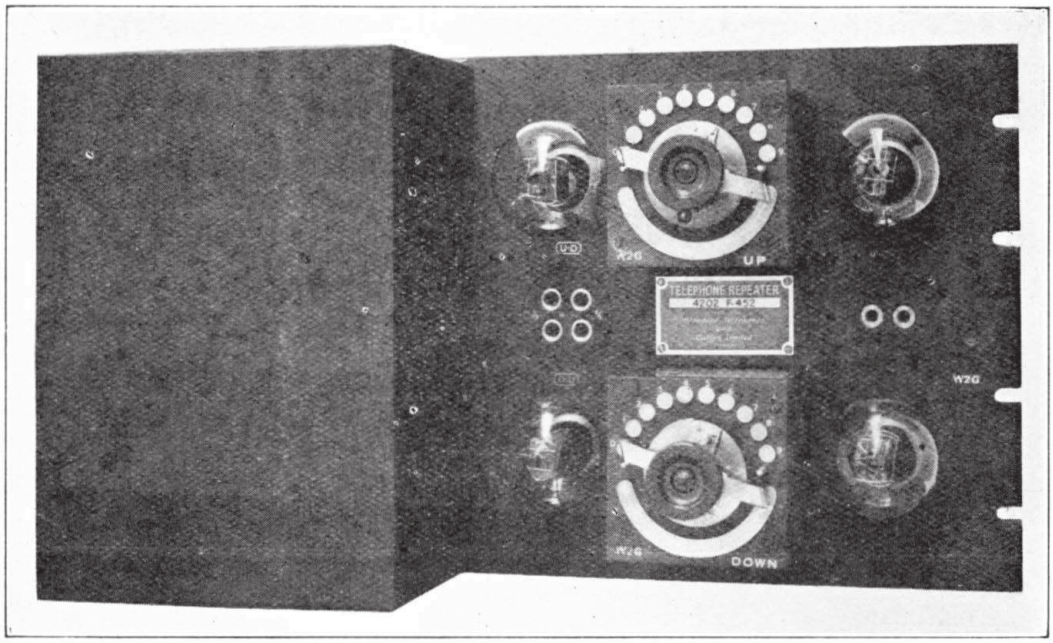


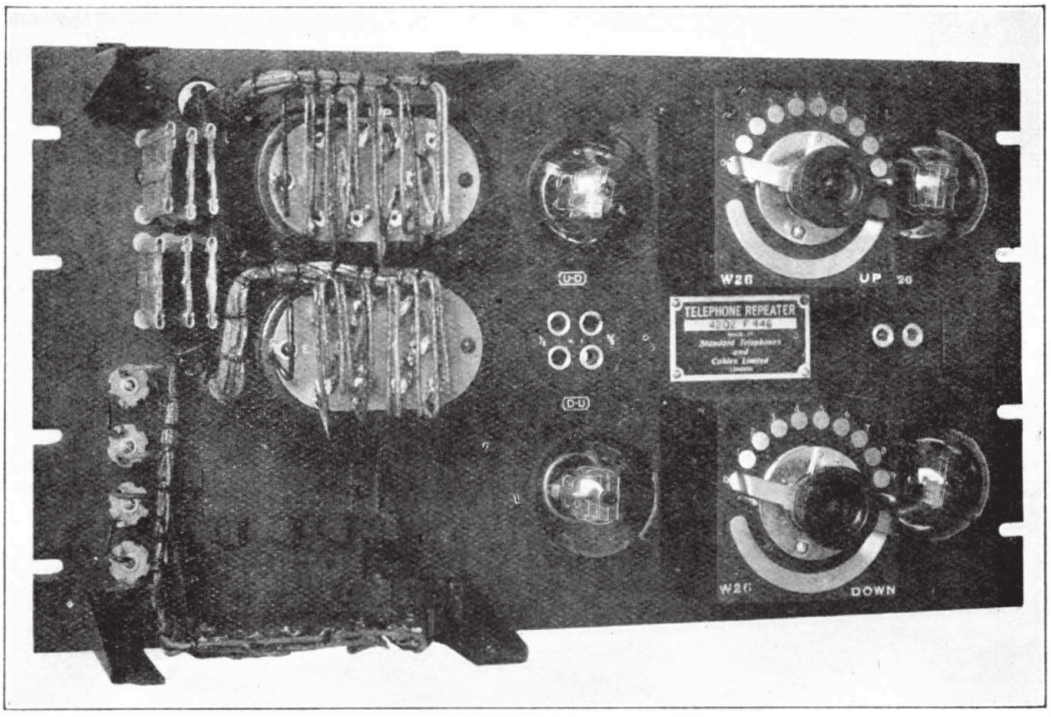
PLATE BATTERY CHARGING AND RINGING MACHINES, LEEDS.



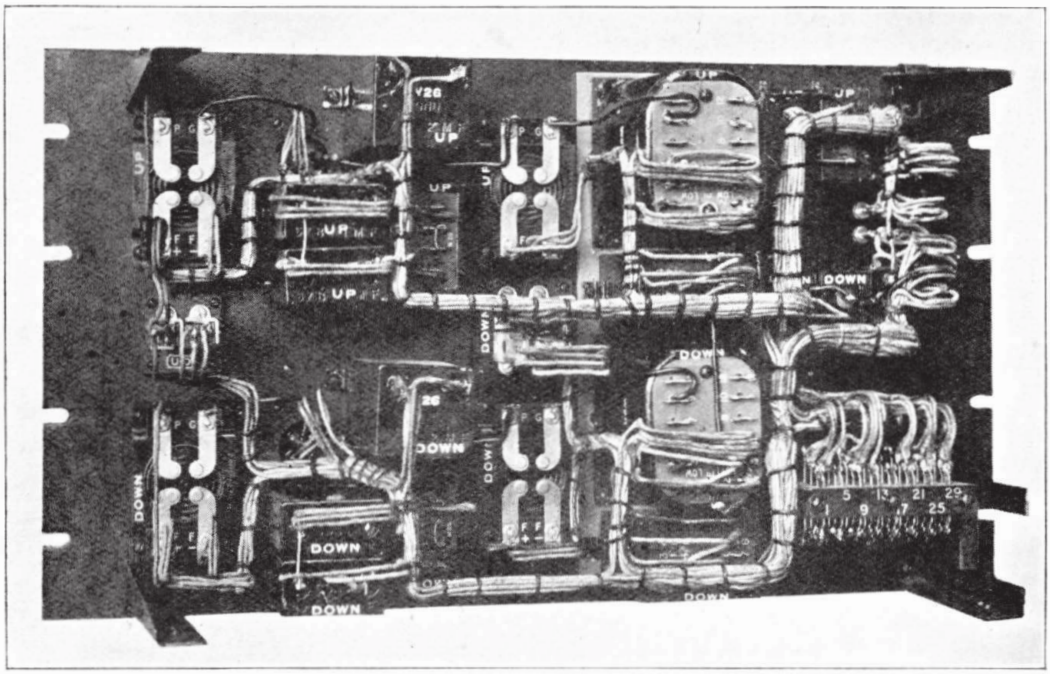
FILAMENTS AND PLATE BATTERIES, LEEDS.



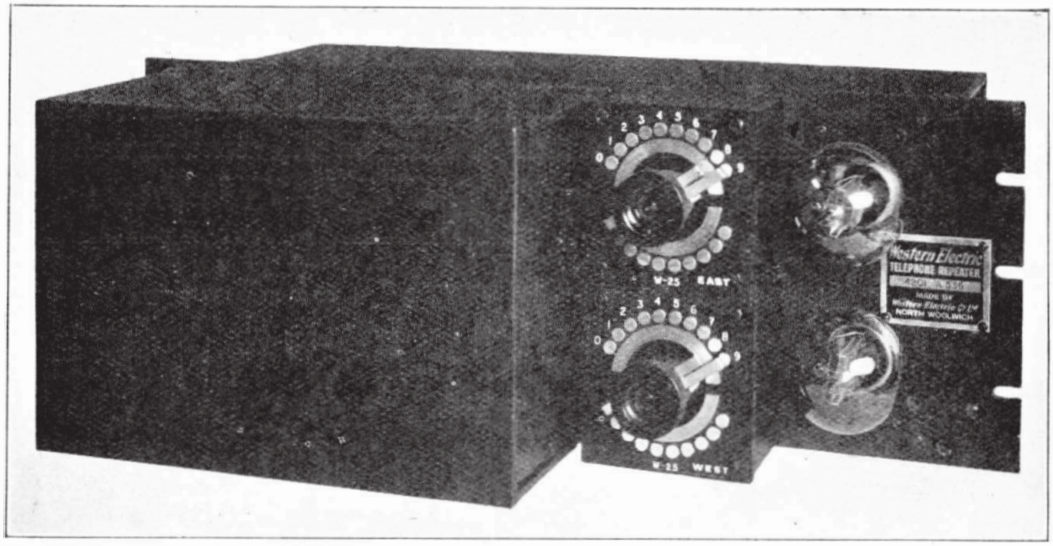
4-Wire Repeater Unit. Front View. Cover on.



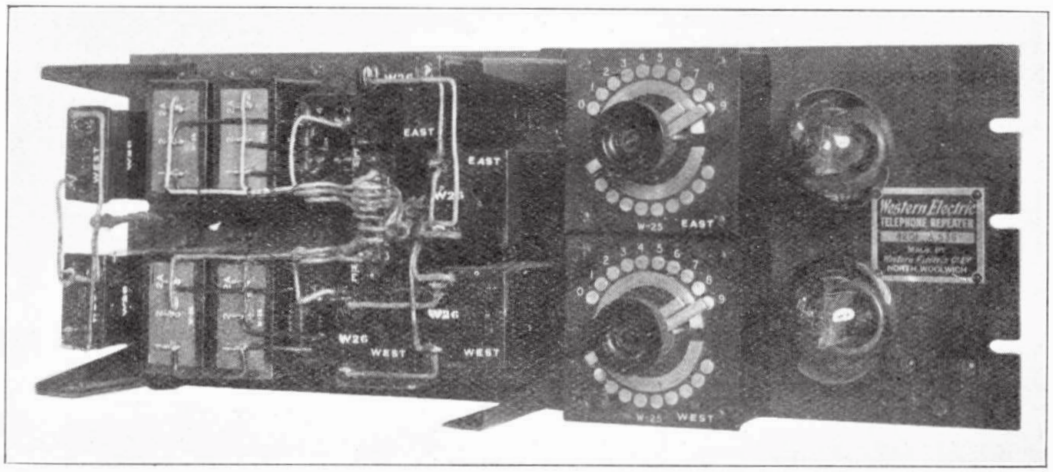
4-Wire Repeater Unit. Front View. Cover off.



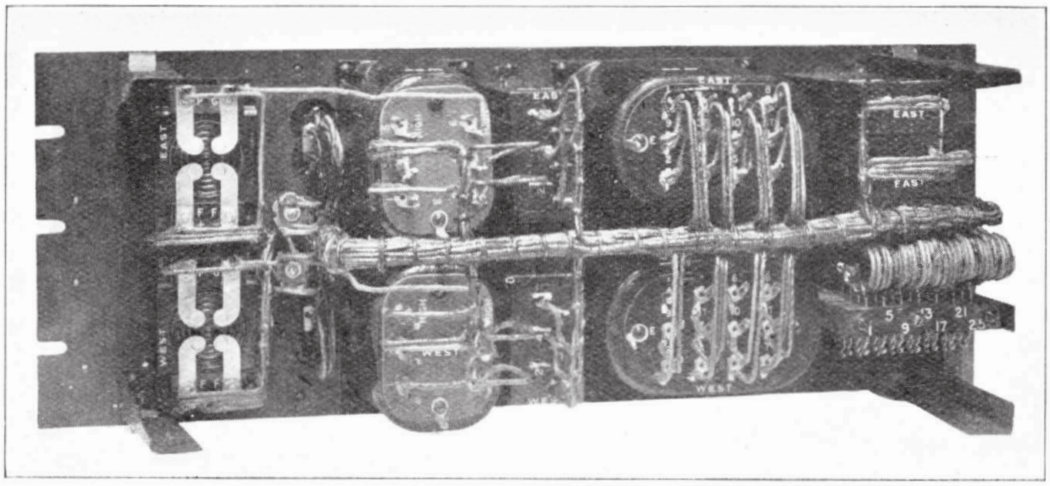
4-Wire Repeater Unit. Rear View. Cover off.



2-Wire Repeater Unit. Front View. Cover on.



2-WIRE REPEATER UNIT. FRONT VIEW. COVER OFF.



2-WIRE REPEATER UNIT. REAR VIEW. COVER OFF.

As a matter of interest the following table gives the initial number of repeaters at the various stations on the route as well as data on various other points:—

	Repeaters 2-wire	Repeaters 4-wire	Vacuum Tubes
London	6	54	228
Fenny-Stratford ...	268	54	752
Derby	308	54	832
Leeds	130	60	500
Catterick	70	50	340
Newcastle	20	50	240
Jedburgh	30	50	260
Edinburgh	50	50	300
Glasgow	—	45	180
Total ...	882	467	3632

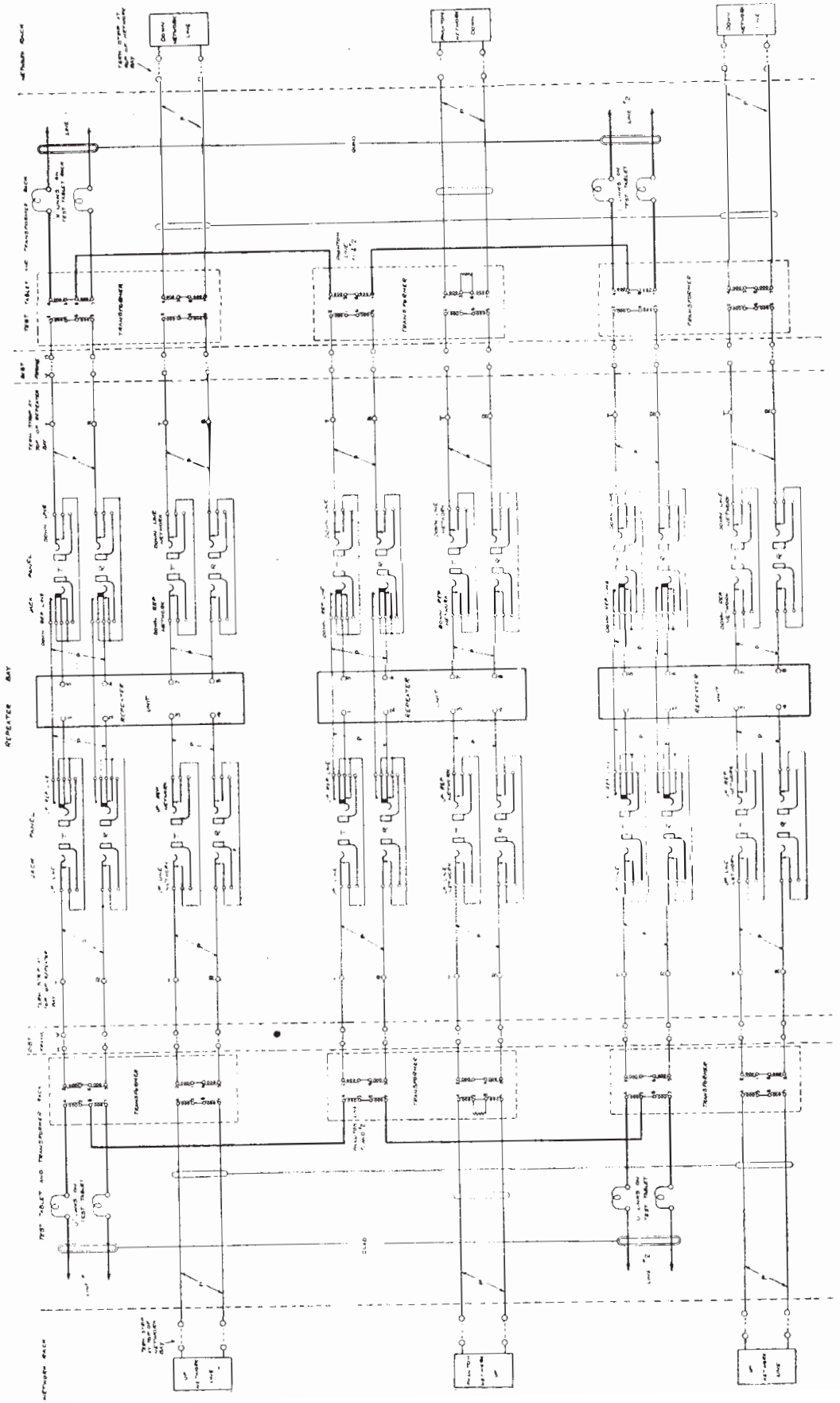


FIG. 14.—SCHEMATIC OF 2-WIRE REPEATERED PHANTOM GROUP, WITH BALANCING NETWORK.

Repeater Circuits.—It will be realised there is of necessity a number of special cases calling for special circuit arrangements in such a network, but it is not felt necessary to emphasise these particular arrangements. Accordingly, only typical arrangements have been dealt with, these, of course, forming the majority of the cases on the North-East route. The following typical circuits are illustrated:—

2-wire repeatered phantom group ... ... Fig, **14.**
2-wire terminal with V.F. signalling ... ... Fig. **15.**
4-wire repeatered phantom group (Through)... Fig. **16.**
4-wire repeatered terminal with V.F. signalling Fig. **17.**

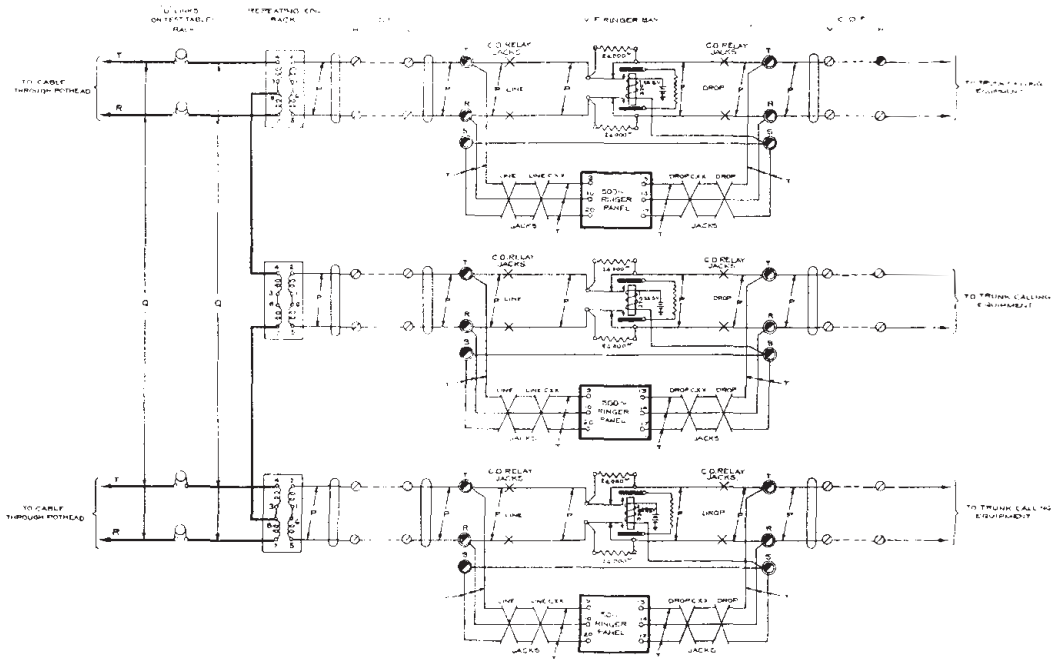


FIG. **15.**—SCHEMATIC OF 2-WIRE TERMINAL WITH V.F. SIGNALLING.

Dealing with the 2-wire through phantom group, the method of connecting the repeaters to the lines and networks is illustrated and shows the U links from which the lines are tested and the jack arrangements by which the repeater units are patched when necessary and are tested with the gain measuring sets. A schematic drawing of a complete 2-wire repeater circuit with its associated battery supply apparatus, operator's telephone and and trunk panel and filament control panels as shown in Fig. **18.** There are several points on this figure which are worth noting. In the first place, the filters are located in the output circuit, which results in a simpler and cheaper design than when they are located in the input circuit. Potentiometers are of the constant impedance type that permits improved impedance of the repeater, and the listening arrangements are such that the

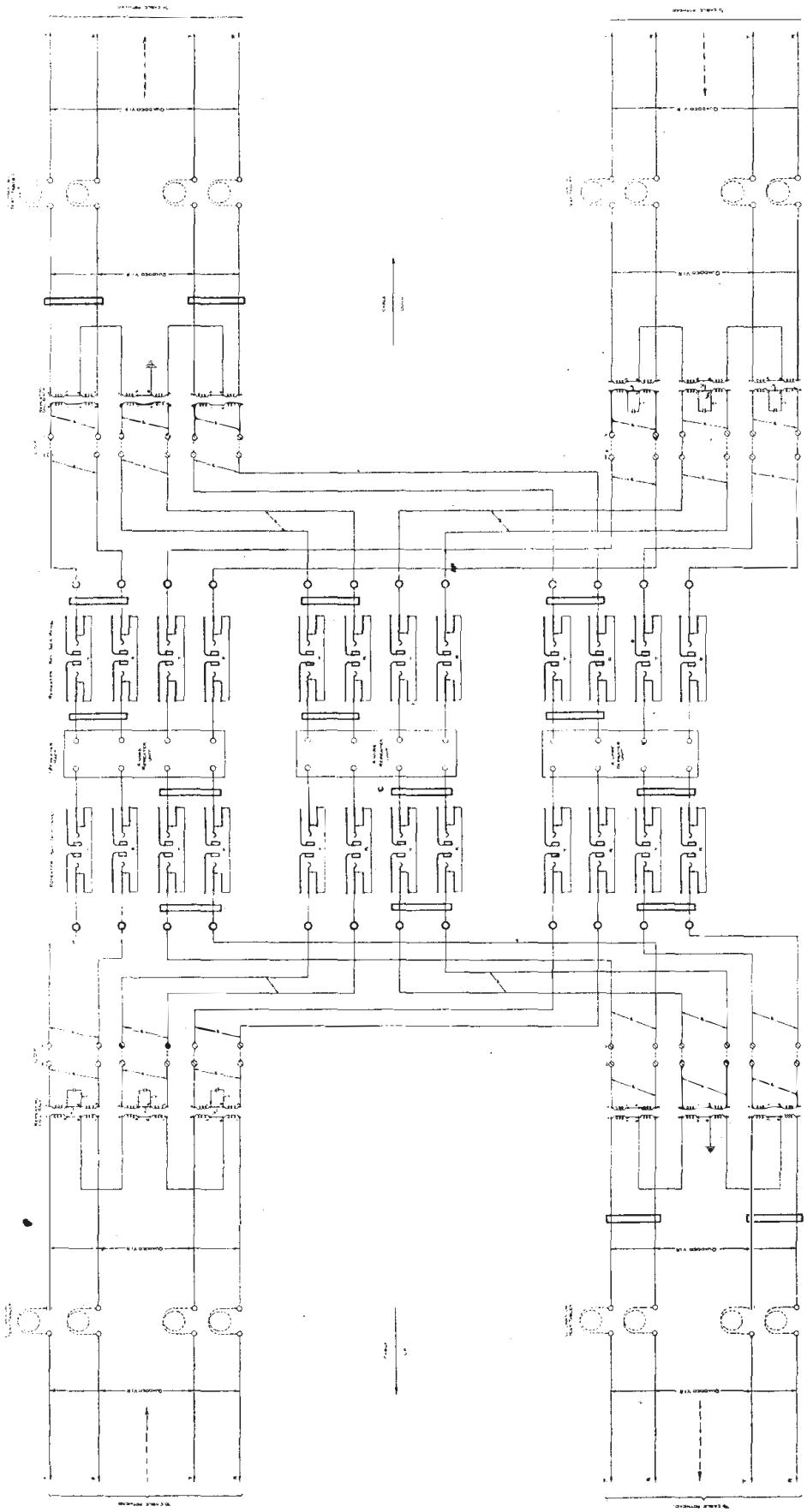


FIG. 16.—SCHEMATIC OF 4-WIRE REPEATERED PHANTOM GROUP.

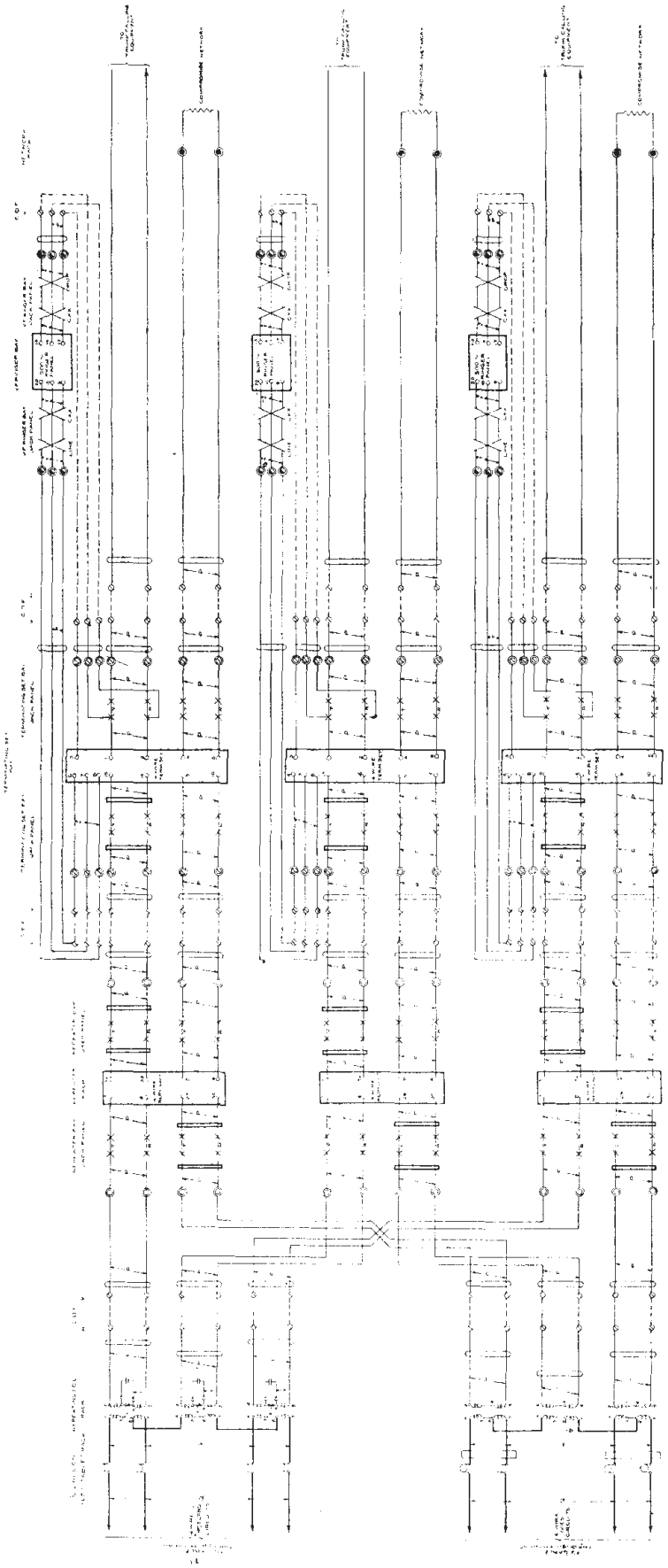


FIG. 17.—SCHEMATIC OF 4-WIRE REPEATERED TERMINAL WITH V.F. SIGNALLING.

repeater attendant can listen and talk in either direction as required or in both simultaneously if necessary. The battery supply arrangements are so designed that the vacuum tubes of two repeater units are worked off one filament circuit, permitting a reduction in the power plant. This arrangement of working necessitates the use of means for reducing the filament cross-talk and the power plant is equipped with a power filter employing electrolytic condensers, thus obviating the necessity for individual filament choke coils.

Since voice frequency signalling is used with these repeater units, there is, of course, no necessity for relaying ringing current at the repeater stations as it is amplified in the same manner as the speech currents, although means are provided for inserting 17-cycle ringers when required.

The basic network used for all 40 lb. medium-heavy loaded circuits is shown in Fig. **19**, and the building-out capacity necessary for each circuit is obtained from a multi-unit condenser containing 10 units, permitting values of capacity to within .001 mf. being obtained up to a maximum value of .1 mf. Since the repeaters are designed to give a better low frequency gain than has been obtained hitherto, it is necessary to employ a network which gives good simulation at low frequencies and this is obtained by means of an excess simulator included in the standard networks, as shown in Fig. **19**.

At the terminal of the 2-wire group as described above, the arrangements shown in Fig. **15** are used. This arrangement consists of the line repeating coils for obtaining a phantom circuit together with the 500 cycle ringer panels and cut-off relays. The ringer panels and cut-off relays are illustrated in more detail in Fig. **20**, which shows the jacks used for testing the ringer panel by means of the ringer test panel shown in Fig. **29**. The ringer panel is equipped with a 500-cycle relay of a new design which permits of the modulating feature used with these frequency ringing circuits for protection against false operation to be obtained from the incoming signalling current. This modulating feature operates the 20-cycle circuit, which immediately follows the voice frequency relay, and the final relays in the train do not operate unless the alternating current operating the voice frequency relay has the correct frequency of modulation.

The test panel associated with these ringers is shown in Fig. **29**, and permits of the time delay feature in the ringer panel being tested and adjusted, as well as checking the complete operation of the panel from the two directions. Facilities are also provided for testing the 20-cycle relays.

The cut-off relay shown in Fig. **20**, when operated, closes the line through a resistance, which is necessary in order to prevent

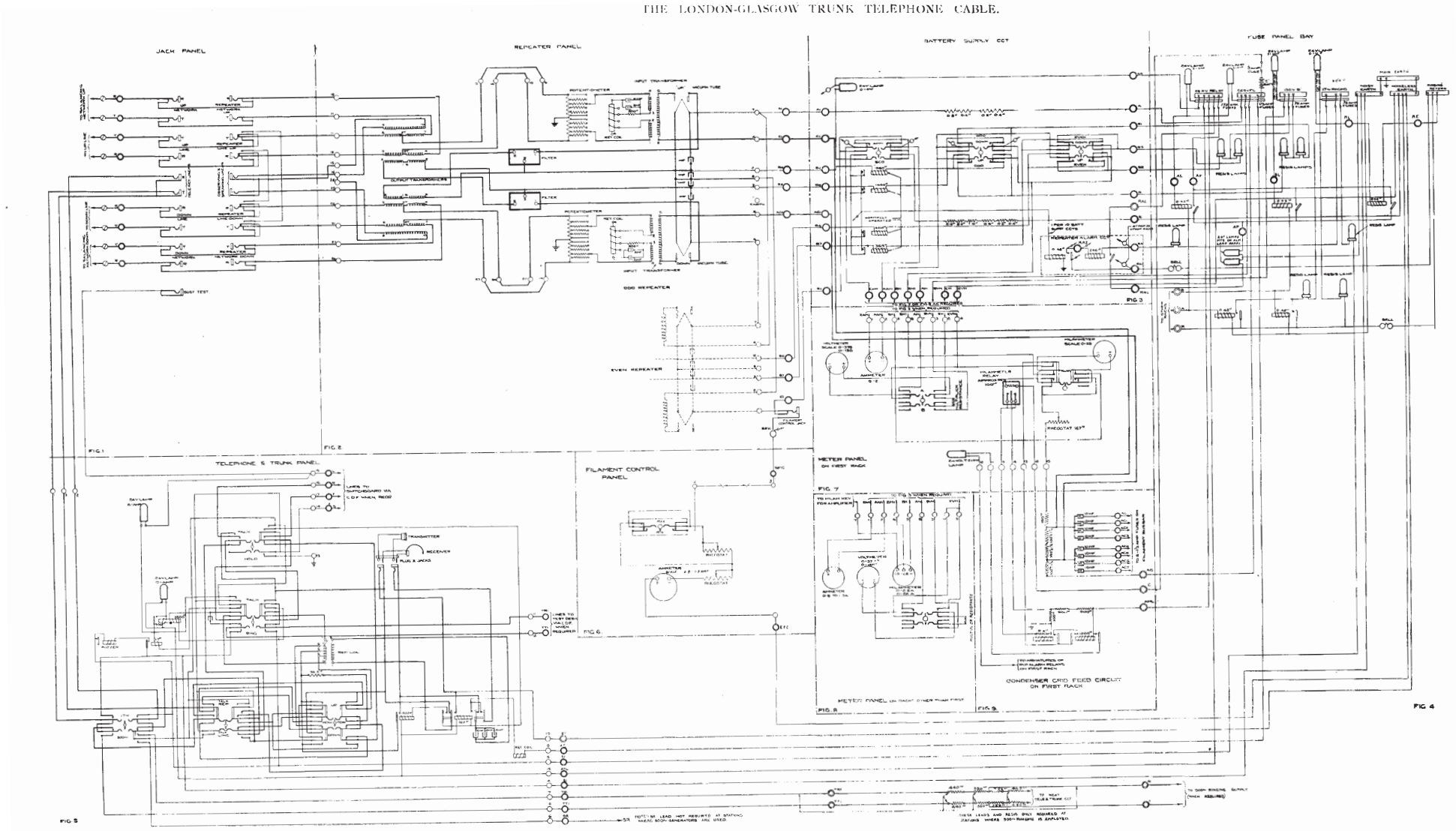


FIG. 18.—DIAGRAM OF 2-WIRE REPEATER CIRCUIT WITH ASSOCIATED APPARATUS. (S.T. AND C. LTD. DRAWING, L 36415).

serious echo currents if the line were open-circuited during the ringing period.

A 4-wire through cable group with repeaters is shown on Fig. **16**, segregation of input and output circuits is shown as well as the jacks used for patching and testing the repeater units. Low frequency corrector condensers are included in the input repeating coils, when necessary, on extra light loaded circuits to equalise the attenuation of a line at the low frequnecies and so prevent excess gain at these frequencies.

The 4-wire repeater unit is shown in Fig. **21**, which shows the unit together with its jacks, telephone and trunk panel, battery supply circuit, meter panels and filament control panel. The listening arrangements are similar to those on the 2-wire repeaters.

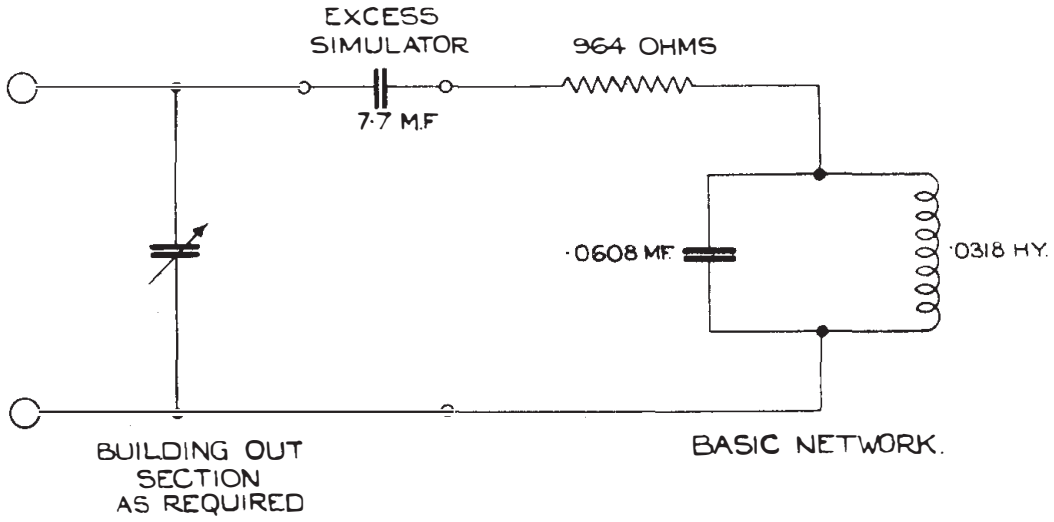


FIG. **19**.—BALANCING NETWORK FOR H-177-107 PHANTOM CIRCUIT.

The gain of the repeater unit is adjusted by means of the tapped input transformer and inter stage transformer, while a fine adjustment is obtained by means of resistances in the output circuit. The repeater unit will cater for medium-heavy loaded lines and extra light loaded lines, the gain frequency curve being adjusted for the former type by means of the retard coil and condenser associated with the first input transformer.

A schematic of the terminating arrangements employed for the 4-wire system is shown in Fig. **17**. This covers the use of terminal 4-wire repeaters, 4-wire terminating sets, and 500 cycle ringer panels. The 4-wire terminating set and the method of connecting the 500-cycle ringer panel to it are illustrated in more detail in Fig. **22**. The operation of the ringer panel is the same as that described for the 2-wire case, except that the cut-off relays are included in the 4-wire terminating set. The 4-wire terminat-

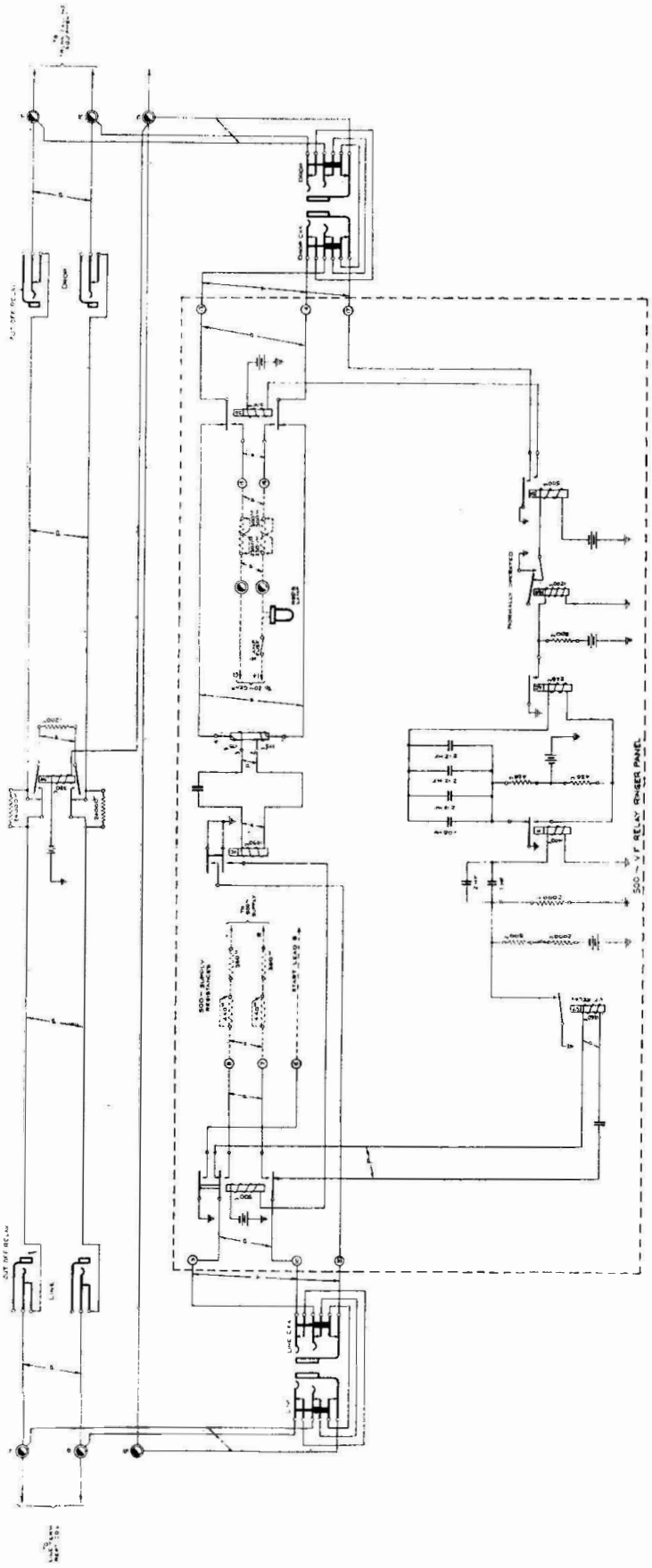


FIG. 20.—SCHEMATIC OF 2-WIRE TERMINAL. 500 CYCLE—20 CYCLE RINGING.

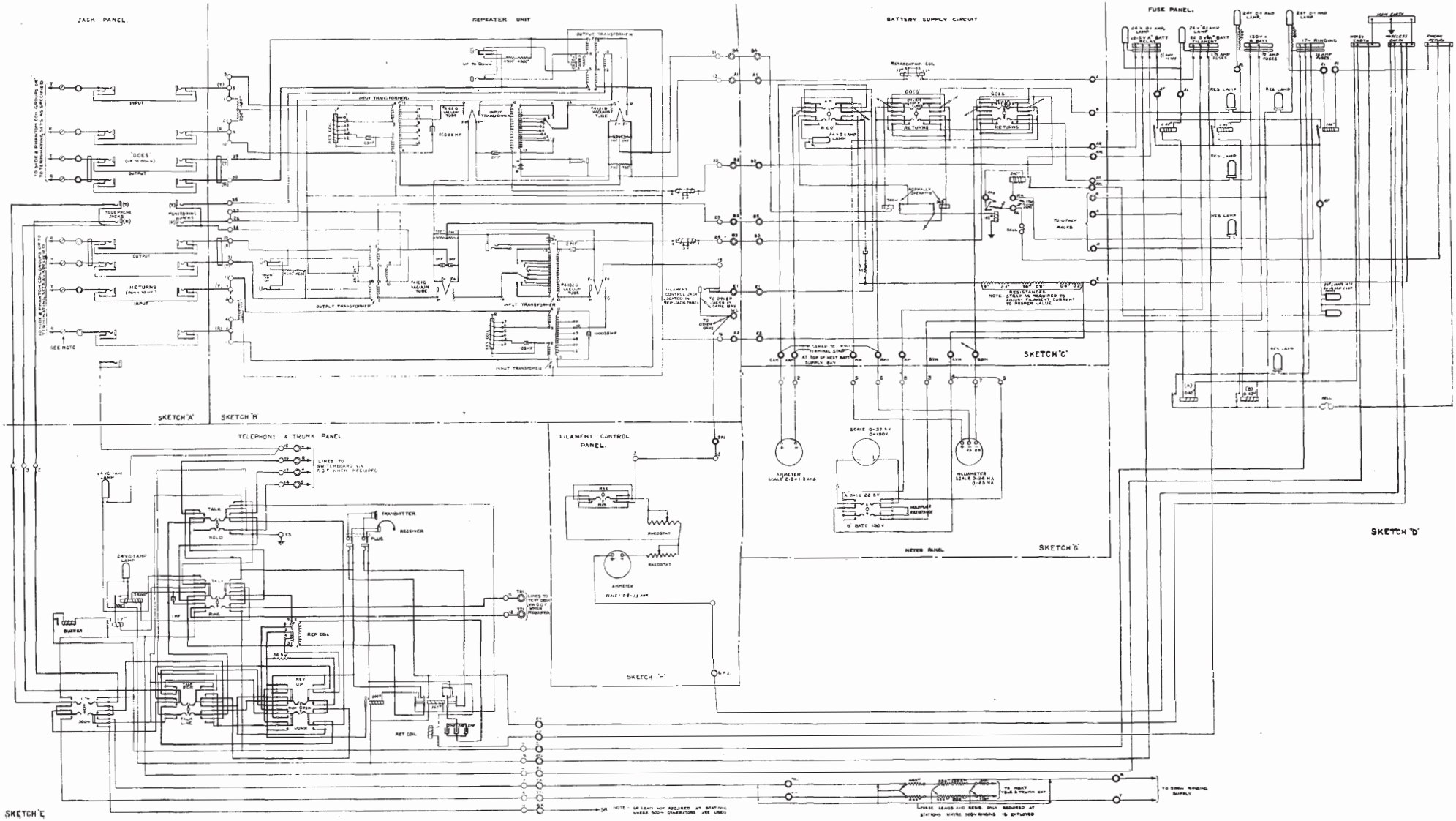


FIG. 21.—SCHEMATIC OF 4-WIRE REPEATER CIRCUIT WITH ASSOCIATED APPARATUS. (S.T. AND C. LTD. DRAWING, L 36416).

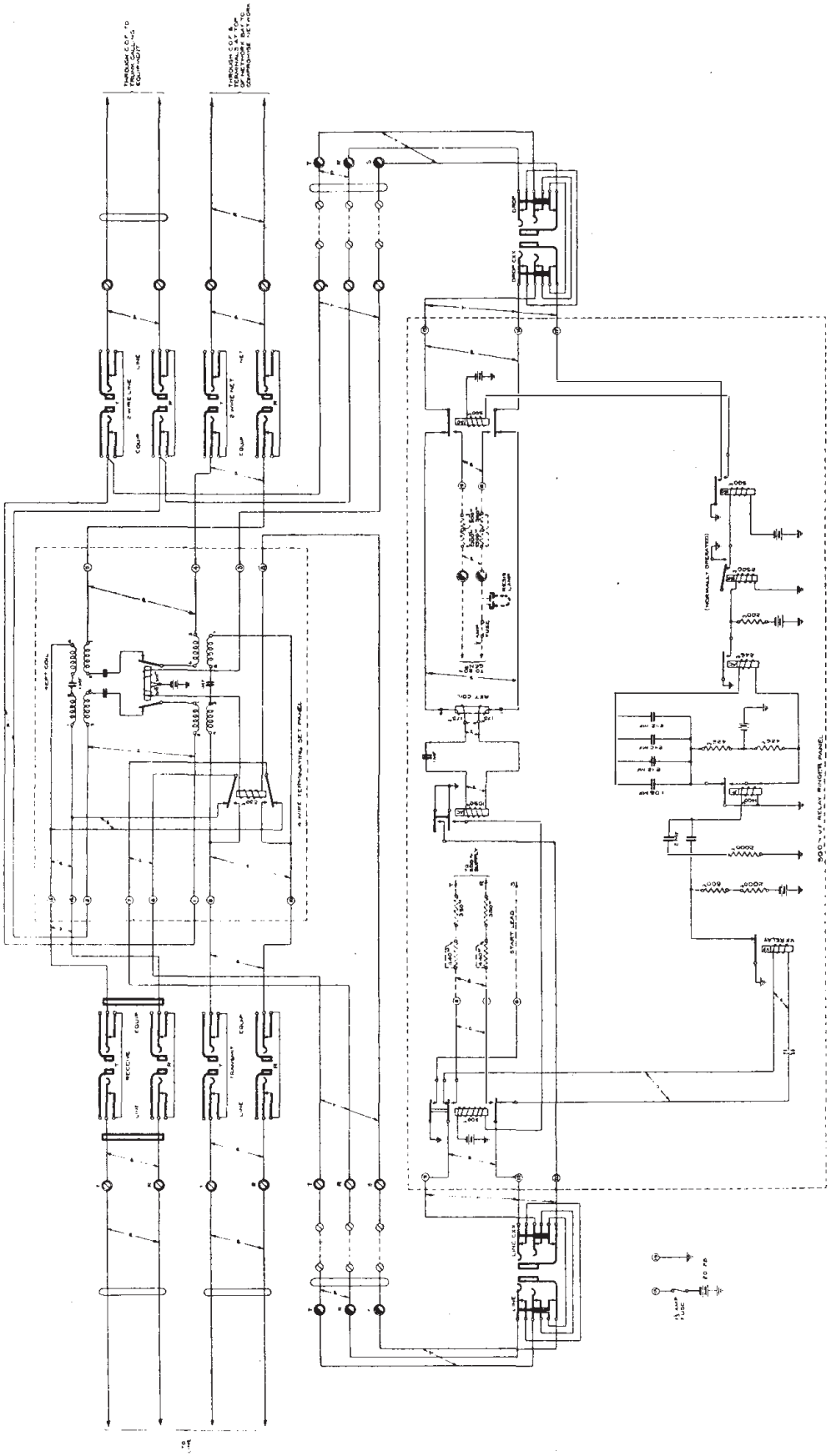


FIG. 22.—SCHEMATIC OF 4-WIRE TERMINATING SET AND METHOD OF CONNECTING.

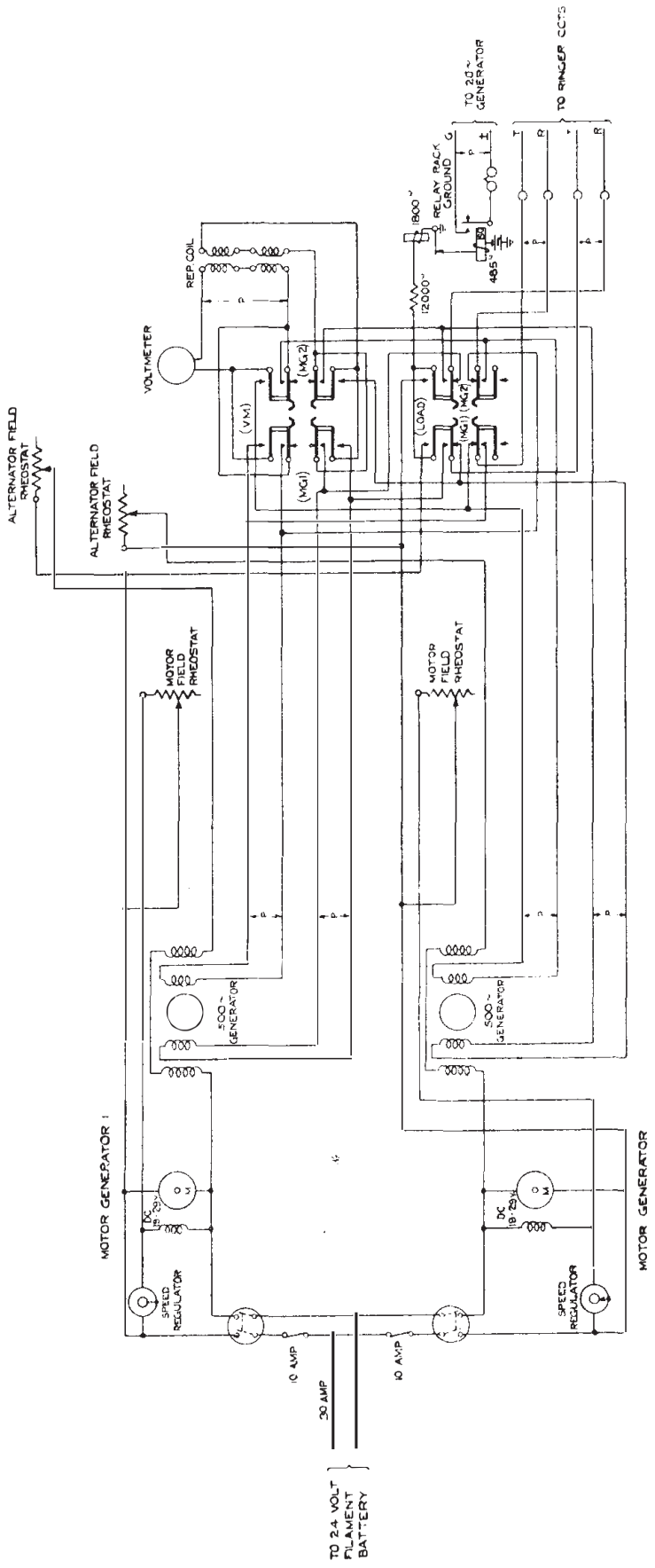


FIG. 23.—VOICE FREQUENCY SIGNALLING MACHINES.

ing set consists of repeating coils and condensers so connected that they serve the double function of a hybrid coil and of a high pass filter.

In connection with the voice frequency signalling arrangements a schematic of the 500-cycle machines and control gear is shown in Fig. **23**. This machine is designed so that its output from the winding is in the form of modulated 500 cycles, thus replacing the old arrangements of commutator output.

Vacuum Tubes.—The vacuum tubes used on the repeaters on the London—Glasgow repeater stations have oxide-coated filaments taking a current of 0.97 amperes. An illustration of one of these tubes indicates the design of the tubes and they are so

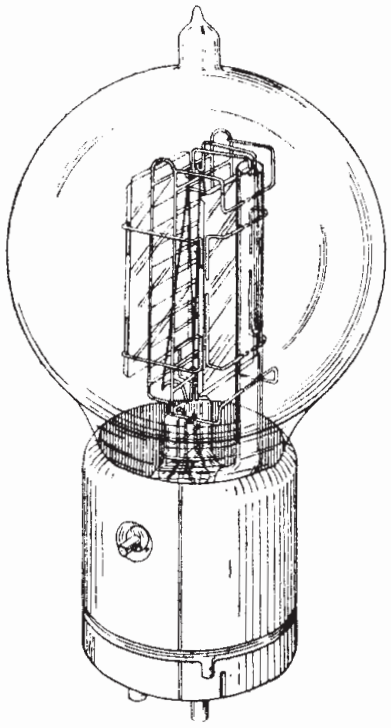


FIG. **24**.—TYPE 4101 D TUBE.

designed that microphonicity is reduced to a minimum. Fig. **27** gives the characteristic of the 4101-D tube under conditions of zero load and when closed through a load impedance of 6000 ohms.

The tube operates normally with a plate voltage of 130 volts and a negative grid voltage of 9 volts. Under these conditions it will be seen from the load curve that the symetric distortion introduced by the tube is negligible.

In order to maintain the overall circuit equivalent under all ordinary conditions of battery fluctuation which occur in practice, vacuum tubes are rejected when the gain of a repeater varies by more than 0.11 βl for a change of filament current from 0.93 amp. to 1.00 amp.

This tube rejection test is made by means of the filament control panel and gain set previously mentioned.

The 4101-D vacuum tube is capable of handling an output power of 0.59 watts, which is a factor to be borne in mind when laying out the transmission level diagrams.

Repeater Apparatus.—Gain frequency curves of the 2-wire repeaters for medium-heavy loaded circuits are shown on Fig. **25** for all potentiometer settings from 1 to 9. These curves show a remarkable uniformity of curve for all settings.

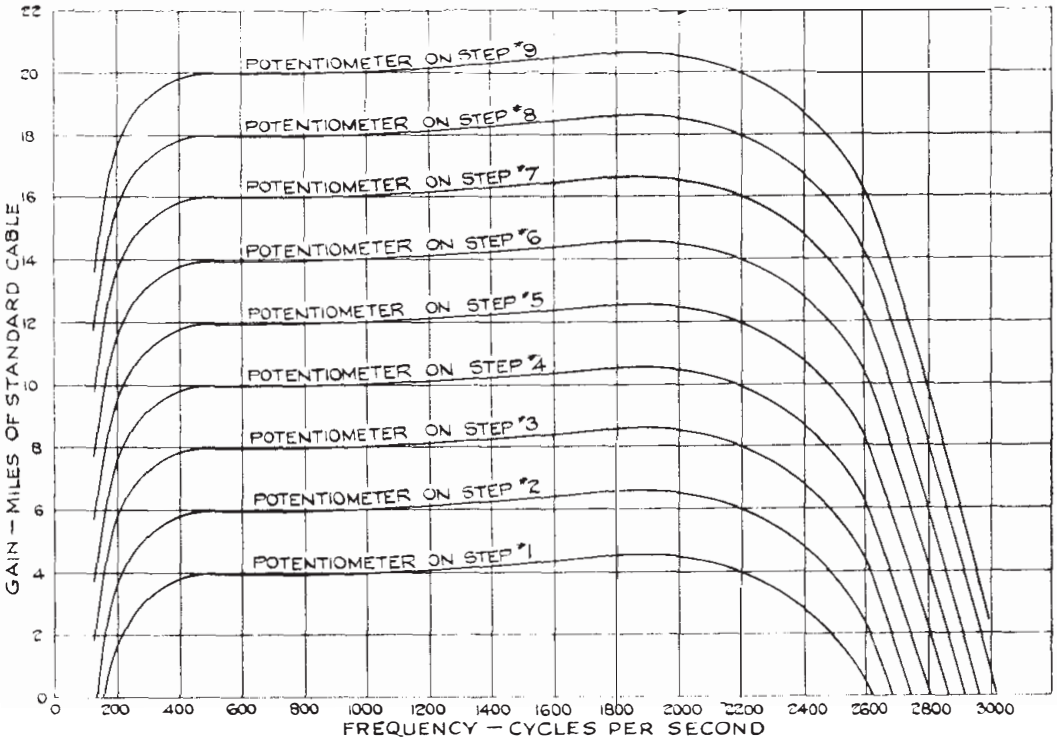


FIG. **25**.—GAIN VS. FREQUENCY. 2-WIRE.

Gain frequency curves of the 4-wire repeater unit are shown in Fig. **26**, the medium-heavy loaded values lying between the two curves shown and various tappings on the retard coil previously mentioned give maximum values at intermediate points. The extra light loaded characteristic is shown below the medium-heavy loaded characteristic.

In setting up a 4-wire medium-heavy circuit the transmitting half of the repeater at the terminal stations is given an extra-light setting having the required 1000-cycle gain obtained from the transmission level diagrams.

All other repeaters, including the receiving halves of the terminal repeaters, are set so that the gain-frequency curve compensates for the attenuation-frequency curve of the previous repeater section. By means of the adjustable tuning circuit mentioned above, it is possible to equalise for any repeater section

between the maximum and minimum lengths met with in practice.

Power Plant.—The principal features of repeater station power plants have been previously described in this Journal, and it is proposed in this article only to refer to those features of the power plants for the repeater stations on the North-Eastern cable which differ from the system previously explained. Photos on pages 126/7, and Fig. **28** illustrate the general arrangement of a typical plant and refer to Leeds Repeater Station as representing the system under consideration, which is distinguished from previous systems by the operation of the batteries on a floating routine.

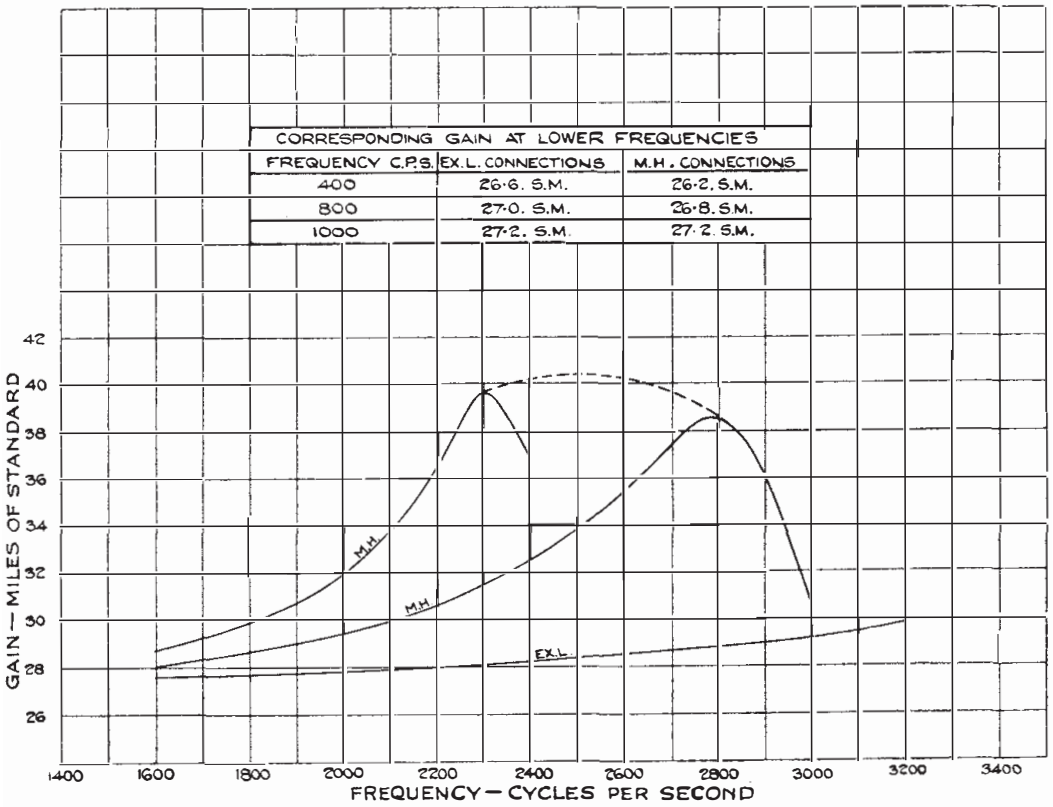


FIG. **26**.—GAIN VS. FREQUENCY. 4-WIRE.

In this instance the power plant supplies both the local telephone exchange and the repeater equipment, and for this reason particular care has been exercised in obtaining a perfectly noiseless supply for the cable circuits. The 22 to 30 volt generators which are used for charging and floating the filament or "A" batteries are of special construction, embodying the usual features of telephone type machines—a large number of commutator segments and armature slots per pole, a long air gap, chamfered pole shoes and skewed armature slots. Such means alone, however, are insufficient to ensure noiseless operation of repeatered circuits, and a special filter is inserted between the generator and the battery when floating. This filter consists of suitable choke coils in the negative lead and a bank of three electrolytic con-

densers connected across the negative and earth leads. The use of electrolytic condensers enables a high electrostatic capacity to be obtained in a small space. Three condensers, each of 1000 mf., are connected in parallel. In this way all noise arising from the machines and from the relay and miscellaneous exchange circuits is prevented from reaching the repeater circuits.

For repeater working the normal permissible voltage variation at the fuse panel bus-bar is ± 0.5 volt. The floating battery system

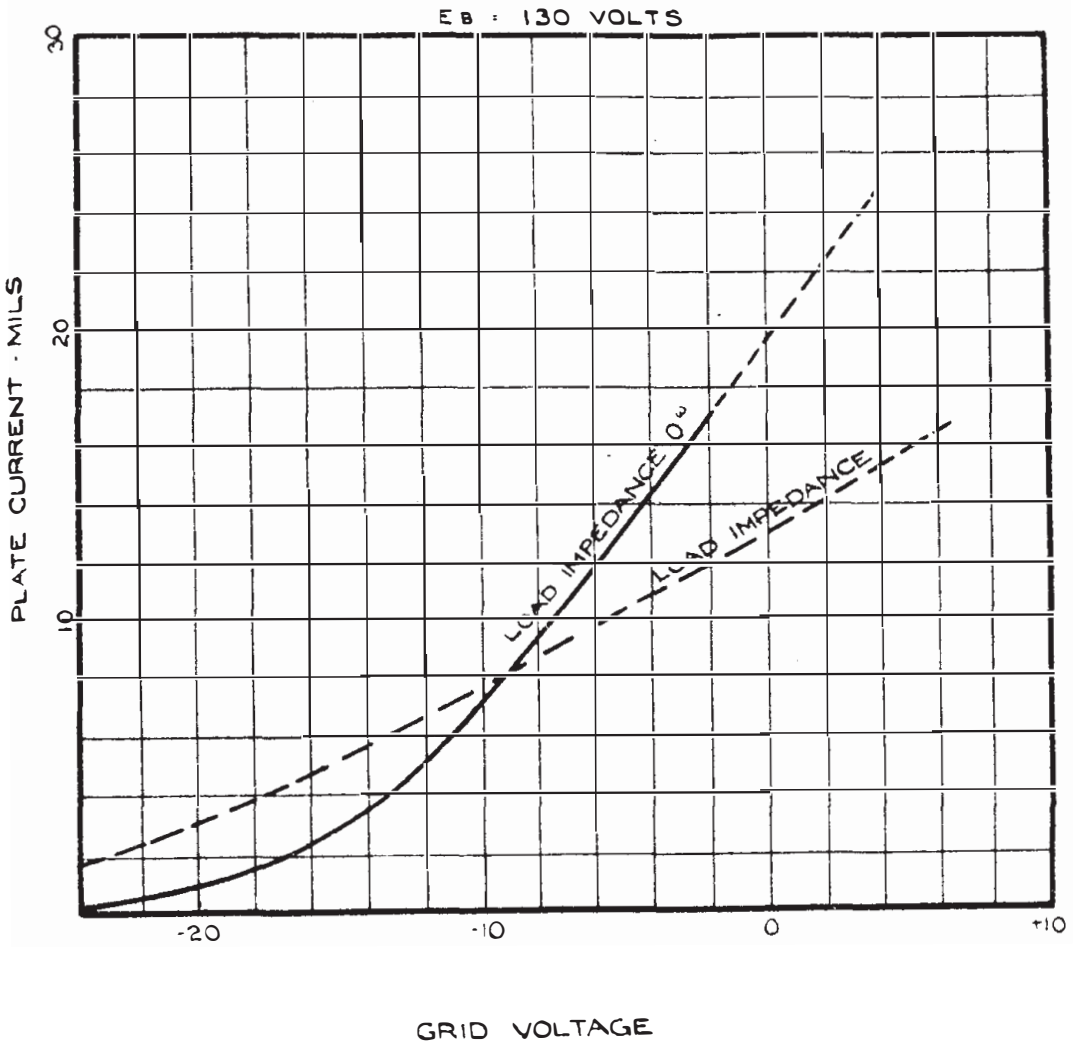


FIG. 27.—CHARACTERISTIC OF TYPE 4101 D TUBE.

provides a ready means of maintaining a steady bus-bar voltage, even over a certain range of load fluctuations, and it is necessary only for the attendant to adjust the generator field regulator when considerable changes of load take place. During periods of failure of the outside power supply the two "A" batteries may be connected in parallel for discharge to the exchange and repeater equipment, in which case a further fall of 0.9 volts is allowable at the fuse panel bus-bars.

The emergency reserve power plant at Leeds consists of an engine coupled to a generator which will produce 60 K.W. at the same voltage and frequency as the normal power supply.

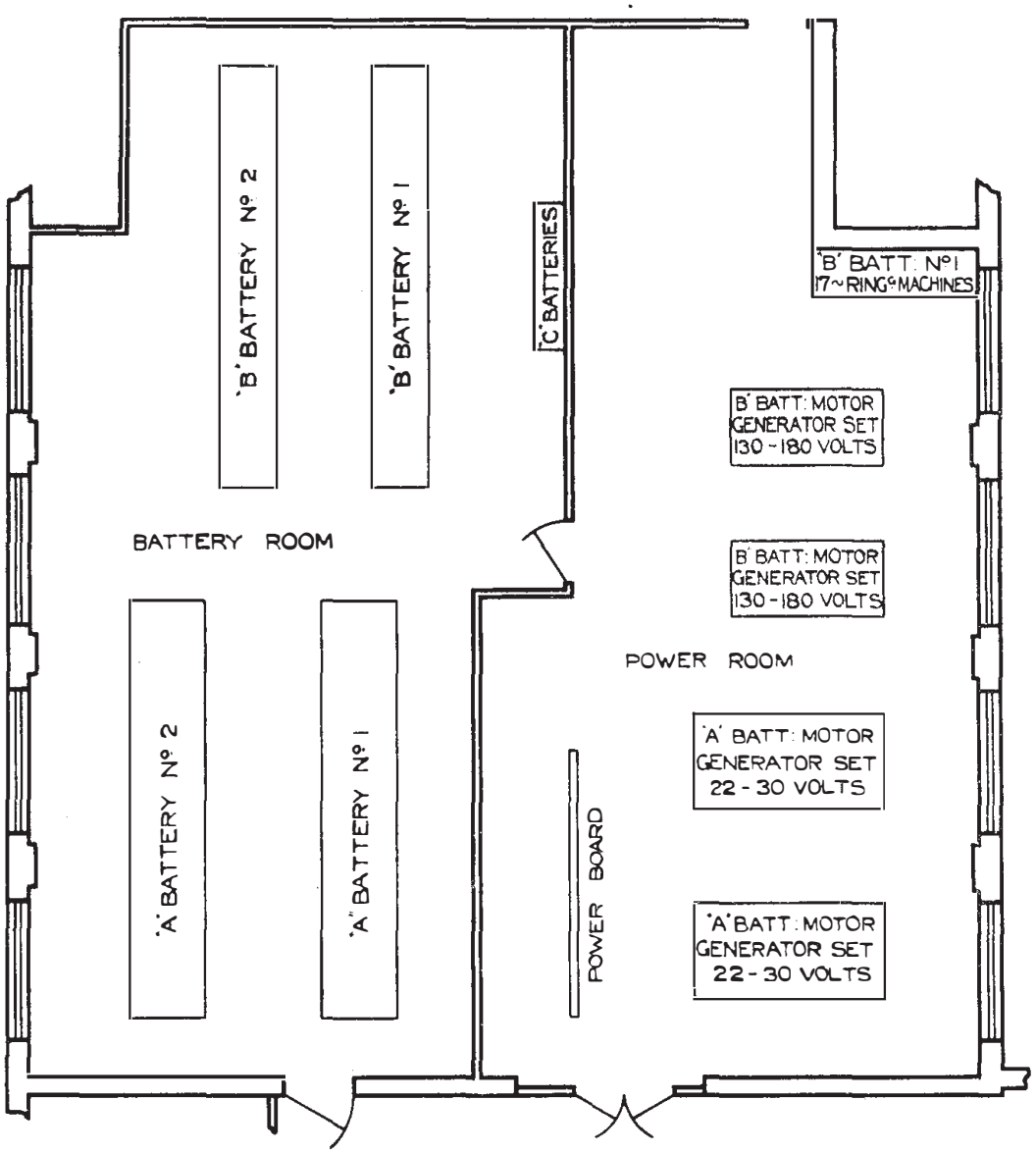


FIG. 28.—LAYOUT OF BATTERY AND POWER ROOM, LEEDS.

The floor plan lay-out of Leeds repeater station battery and power rooms is shown in Fig. **28**, these rooms being located adjacent to the repeater room on the second floor. The equipment is so arranged as to require the shortest possible length of cabling between the batteries, machines and apparatus racks.

The duplicate filament or "A" batteries each consist of 11 wood lead-lined cells with an initial capacity of 5000 ampere hours at the 9 hour rate, suitable for extension to a capacity of 7500 ampere hours at the same discharge rate. The batteries are

illustrated on page 127, the space in the cells available for extension being clearly shown.

The duplicate plate, or " B " batteries, each of 65 wood lead-lined cells, are arranged for initial and ultimate capacities of 150 and 300 ampere hours respectively at the 9 hour rate. These batteries, mounted on double tier wooden stands, are seen in the background of the same Fig. The voltage limits for the " B " batteries are 125 to 135 volts measured at the repeater fuse panel, which limits are readily met by charge-discharge operation.

Duplicate grid, or " C " batteries, are supplied, each consisting of 5 glass cells of 20 ampere hours capacity at the 9 hour rate for both the initial and ultimate repeater equipments. The voltage limits for the " C " batteries are 9.5 to 11 volts measured at the repeater fuse panel. The " C " batteries are operated on a charge —discharge routine, charge being effected from the " A " battery bus-bar through a suitable resistance.

The whole of the above batteries are of the Chloride Co.'s manufacture.

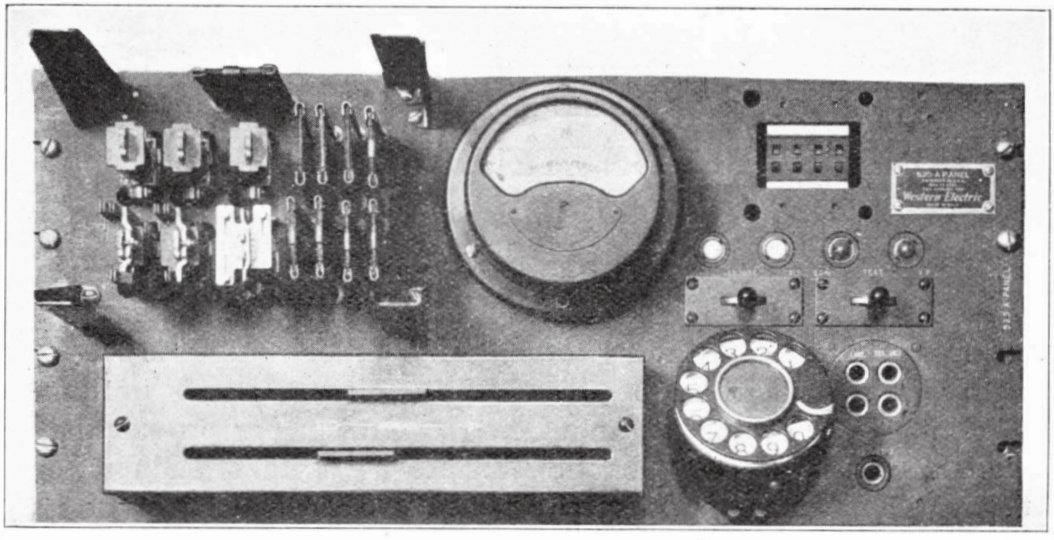


FIG. 29.—RINGING TEST PANEL.

A general view of the " A " battery machines and power board is shown on page 126. Each of these motor generator sets consists of a Crompton Co.'s slip ring induction motor operating on a 200 volt, 2-phase, 4-wire 50 cycle supply and direct coupled to a 22 to 30 volt, 650 ampere telephone type generator, as mentioned above. The motor-starting panel for these machines may be seen on the extreme left of the power board.

Two 130-180 volt, 50 ampere, " B " battery motor generator sets are provided for charging purposes, the generators of which are ordinary commercial type machines manufactured without

special restrictions regarding commutator ripple. One of these machines is shown on page 127. The photo also shows the two 17 cycle ringing machines which are provided, one for operation from the outside power supply and the other suitable for running from the "A" batteries. The line driven machine is normally used and the battery driven dynamotor is operated only during periods of power supply failure.

The power board mounts the necessary switchgear, instruments and meters for the machines and batteries described above and calls for no further comment.

We are indebted to the International Standard Electric Corporation for much of the technical detail and the diagrams included in this article; and we desire to take this opportunity of acknowledging the extent to which the present advanced stage of the art of long distance cable telephony has been due to the basic work of the Bell System Laboratories of the American Telephone and Telegraph Company and to the information published in their technical literature.

A.B.H.

LONDON—BERLIN TELEPHONE CIRCUIT.

On the 15th March a night telephone service with Germany was opened. Communication was established with Berlin, Hamburg and Cologne. This limited service is merely a temporary expedient pending the introduction of a full time service later in the year, when the third Anglo-Dutch Cable is brought into use. The Hamburg and Cologne circuits are provided by extending two of the London-Amsterdam Trunks. Since the Berlin Circuit had to be specially dealt with on account of its greater length some details of the arrangements made may be of interest.

In the first instance an attempt was made to establish communication between London and Berlin by extending a London-Amsterdam circuit as in the case of Hamburg and Cologne. It was found, however, that sufficient volume could not be ensured to permit of reasonable extension. The London-Amsterdam circuit used was made up of a two-wire circuit on underground conductors London to Aldeburgh, submarine cable to Domburg, and thence underground Domburg to Amsterdam, with repeaters at Aldeburgh and Middelburg. For the Berlin circuit a repeater was introduced at Amsterdam. From Amsterdam overhead conductors continued the circuit to Münster, between which town and

Berlin a four-wire underground circuit was used with repeaters at Münster, Bassum, Hanover, Magdeburg and Berlin.

As a result of the preliminary trials it was decided to make the London-Amsterdam section of the circuit four-wire. The section Amsterdam-Münster had to remain as a two-wire circuit as spare conductors were not available to make the circuit four-wire throughout.

Fig. 1 indicates the composition, lengths and gauges of conductor and the attenuation lengths of the various sections of line, as finally made up, and also the location of the repeater stations. The total length of the circuit is 877 miles.

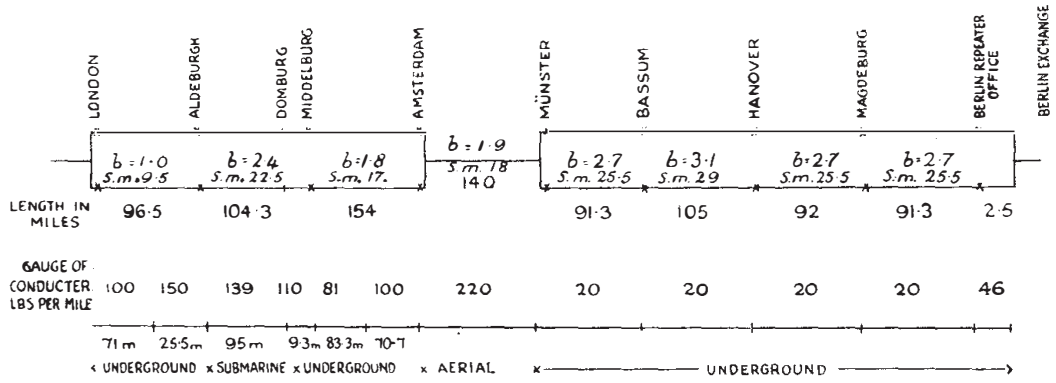


FIG. 1.—MAKE-UP AND PARTICULARS OF CIRCUIT.
b = Attenuation length (βl).

From a study of the attenuation of the various sections of the circuit provisional settings of the repeater gains were arranged. Transmission measurements were then made over a range of frequencies to determine the transmission levels at the various stations and final adjustments were then made to obtain suitable transmission levels and reasonably uniform transmission over the frequency range of commercial speech.

The following table gives the results of tests made when transmitting in the two directions:—

Frequency $\omega\ (=2\pi f)$	London to Berlin. Transmission level at		Berlin to London. Transmission level at	
	Amsterdam	Berlin	Amsterdam	Berlin
	Standard miles.		Standard miles.	
4000	+ 11.3	− 8.0	− 1.9	− 7.5
5000	+ 10.9	− 10.3	− 1.0	− 8.0
6000	+ 11.3	− 9.4	− 2.3	− 9.4
8000	+ 10.3	− 13.2	+ 3.8	− 6.3
10000	+ 8.9	− 11.1	+ 7.0	− 5.0

\+ = above transmission level at the sending end.
− = below ,, ,, ,, ,, ,,

Taking the efficiencies at $\omega = 5000$ it will be seen that the standard cable equivalent London to Berlin is about 10.3 standard miles, and in the direction Berlin to London 8.0 standard miles. The measurements were made by sending into the circuit at each end in turn the equivalent of 1 milliwatt into an impedance of 600 ohms, and measuring the voltage across the circuit at intermediate and terminal points. The readings were corrected for impedance if the circuit differed from 600 ohms in impedance. The readings given for Amsterdam were taken on the output side of the repeater.

It will be noticed that at the higher frequencies there is a difference in the efficiencies in the two directions. As this did not interfere with satisfactory speech steps were not taken to correct it before bringing the circuit into use.

In a telephone circuit it is not practicable to so arrange the impedance of the terminal apparatus that the whole of the received energy is absorbed in the receiving apparatus. A portion of the energy is therefore reflected back to the sending end. In a short circuit the reflected energy is so quickly transmitted that it becomes merged with the ordinary side-tone in the receiver, and is not noticed. In a long circuit without telephone repeaters the reflected energy returns later, but is so attenuated as to be still unnoticed. In the case of the London-Berlin circuit, however, the time of transmission is much greater than the normal and, owing to the attenuation having been greatly reduced by the introduction of repeaters, the reflected energy is considerable and is relatively much delayed with respect to the transmitted speech. In consequence, unless steps were taken to prevent it, the reflected speech currents would cause the speaker to imagine that the listener was trying to interrupt him, his own speech being heard as an echo.

In order to overcome this difficulty "echo suppressors" have been installed in London and Hanover. This apparatus renders the Berlin-London side of the circuit inoperative when speech is being transmitted from London to Berlin and vice versa.

For a description of the "echo suppressor" as used in London reference should be made to a paper by Messrs. Robinson and Chamney, read before the Institute of Post Office Electrical Engineers, entitled "Recent Research Work on Telephone Repeaters" (Professional Paper No. 99).

It should be mentioned that, in addition to the true "echo" effect, circulating currents due to inevitable out-of-balance conditions at the junction between the four-wire and the two-wire portions of the circuit are also returned to the sending end and operate in the same manner as the true echo. The "echo suppressors" stop these currents also, and it is for this reason

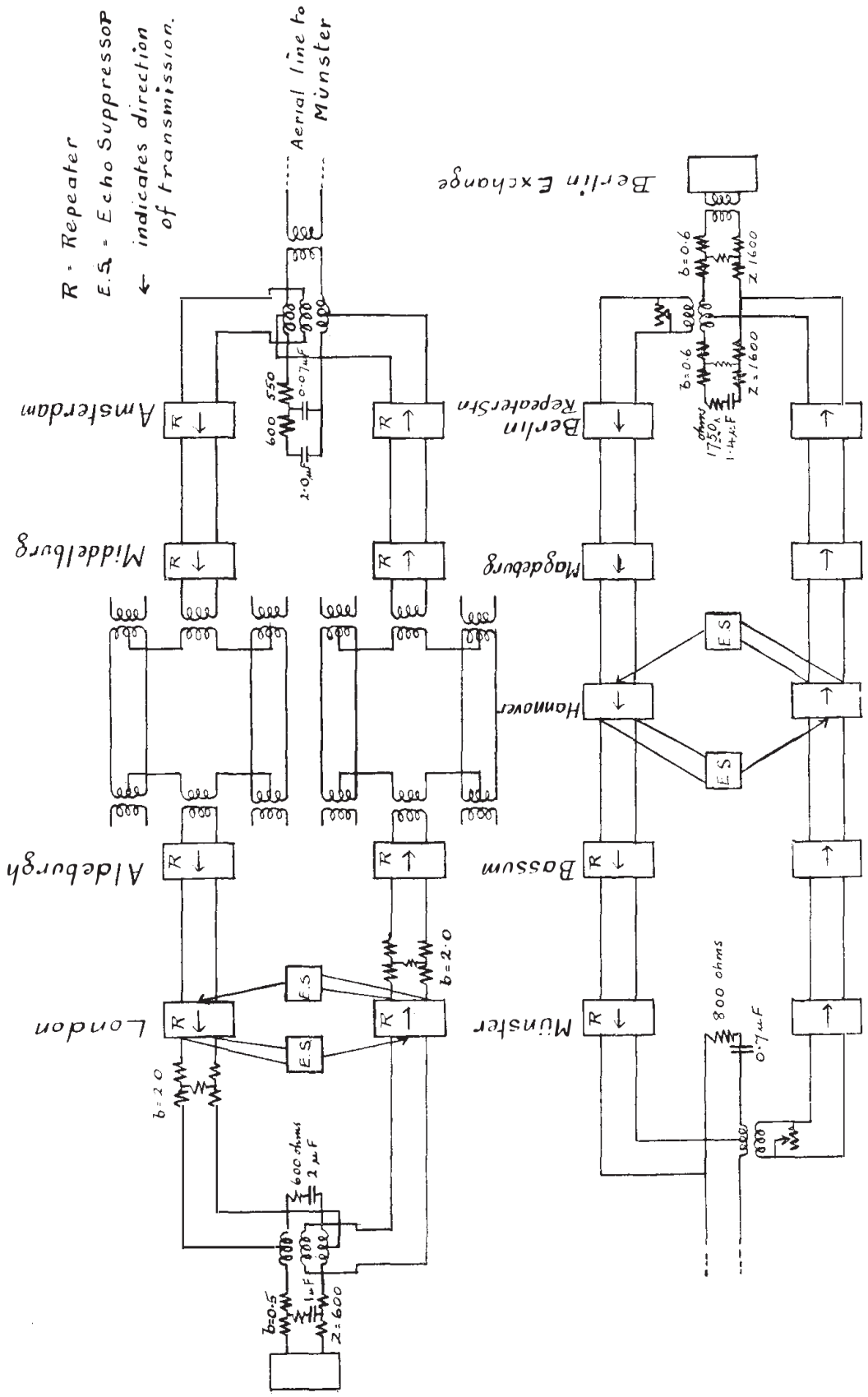


FIG. 2.—CIRCUIT ARRANGEMENTS, SHOWING POSITIONS OF ECHO SUPPRESSORS.

that an " echo " suppressor has been provided for each four-wire section. Fig. **2** shows the circuit arrangements.

At the London end of the circuit a section of artificial cable is connected between the output side of each repeater and the line to enable the maximum amplification of the repeater to be used without unduly increasing the transmission level on the line. This arrangement makes available a greater voltage for operating the " echo suppressors " and the latter thus operate more efficiently with weak speech currents than they would do otherwise.

It will be noticed that phantom circuits are used in the submarine cable.

Signalling is effected by means of 500 cycle alternating current. The energy used is within the scope of the telephone repeater valves and the signalling current is amplified in the same way as ordinary speech currents. Intermediate ringing repeaters with their attendant relay troubles are thus eliminated. Reference to the table of transmission values will show that the efficiency is good at the lower frequencies and this is necessary in order that the ringing currents shall be properly maintained. A test at a frequency of 500 cycles ($\omega = 3140$) showed the efficiency to be practically the same as that at $\omega = 4000$.

Special relays designed to respond to the 500-cycle current are used to receive the signalling current and these relays operate ordinary telephone type relays which send out 16-cycle current to the normal exchange signalling equipment. The operators ring in the usual manner with 16-cycle current and this operates relays which cause 500-cycle current to be passed out on one side of the four-wire portion of the circuit. A diagram of the terminal arrangements for 500-cycle signalling will be found on page 279, Vol. 18, of this Journal.

The echo suppressors were manufactured by the General Electric Coy. (Peel Works, Coventry).

As already explained, the arrangements are only of a temporary character. When the full day service is opened the Berlin circuits will be operated as four-wire underground circuits throughout, except in the submarine cable section which will be worked on a two-wire basis. Repeaters will then be installed at Marks Tey instead of London and the Middelburg station will be replaced by one at Domburg.

[NOTE.—The Anglo-Dutch No. 3 Cable has been laid from Domburg to Aldeburgh and tests prove it to be efficient. We hope to give a description of this cable in our next issue.—ED., *P.O.E.E.J.*]

AUTOMATIC TELEPHONE EXCHANGES IN AMSTERDAM. MAINTENANCE EXPERIENCE.

By Dr. Ir. Ch. E. A. Maitland.

A short description will be given of the installation of the telephone system in Amsterdam.

There are now (1925) four main exchanges and one satellite, viz.:—

2nd level South, Tenier Street. C.B.2 full automatic.
3rd ,, Central, Singel Street. C.B.3 full and semi-automatic.
4th ,, North, Raadhuis Street. C.B.4 semi-automatic.
5th ,, East, Middenweg. C.B.5 full automatic.
6th ,, of which the bulk of the 1st G.S. and 2nd G.S. are placed in the office North, and one satellite is installed on the opposite side of the river at the Wingerdweg C.B.6 (full automatic).

All exchanges are of the Siemens and Halske Strowger system. They work with impulses with earth return. The switches are controlled electro-mechanically by sequence switches. These sequence switches are of a minor switch type with banks and wipers.

The toll traffic is served by means of manual switchboards, except in the satellite of the 6th level, where the toll traffic is distributed automatically.

Table I gives various information about the exchanges. The semi-automatic exchanges are being altered gradually to become full automatic. The figures under 9 and 10 relate to the load during the peak hour 10—11 in the morning for January, 1925. They hold for normal working. On special days higher figures are reached, for example 22500 for C.B.4.

The maintenance of a telephone exchange can be divided into two parts:—

1. Preventive measures.
2. Removal of faults.

The first includes the measures for revealing and removal of faults before they have caused disturbance to traffic. The second refers to the removal of faults which have been revealed by causing disturbance to traffic. The statistics in the first category serve as a judge of the work of the maintenance staff, those in the second category show the quality of the maintenance.

The sharp demarcation of the different types of faults in the maintenance statistics would, however, cause insurmountable

trouble. For instance, if a fault is found by the patrol it is by no means sure that a fault of one or another kind has not already arisen in a connection, which, however, has given no cause for a complaint and has not been advised in any other way.

Conversely, the fault may have been noticed owing to supervisory signals, among others, those due to a temporary overload of the switching apparatus, which are therefore not caused by any technical fault. For these reasons it is convenient to divide the various types of faults as follows:—

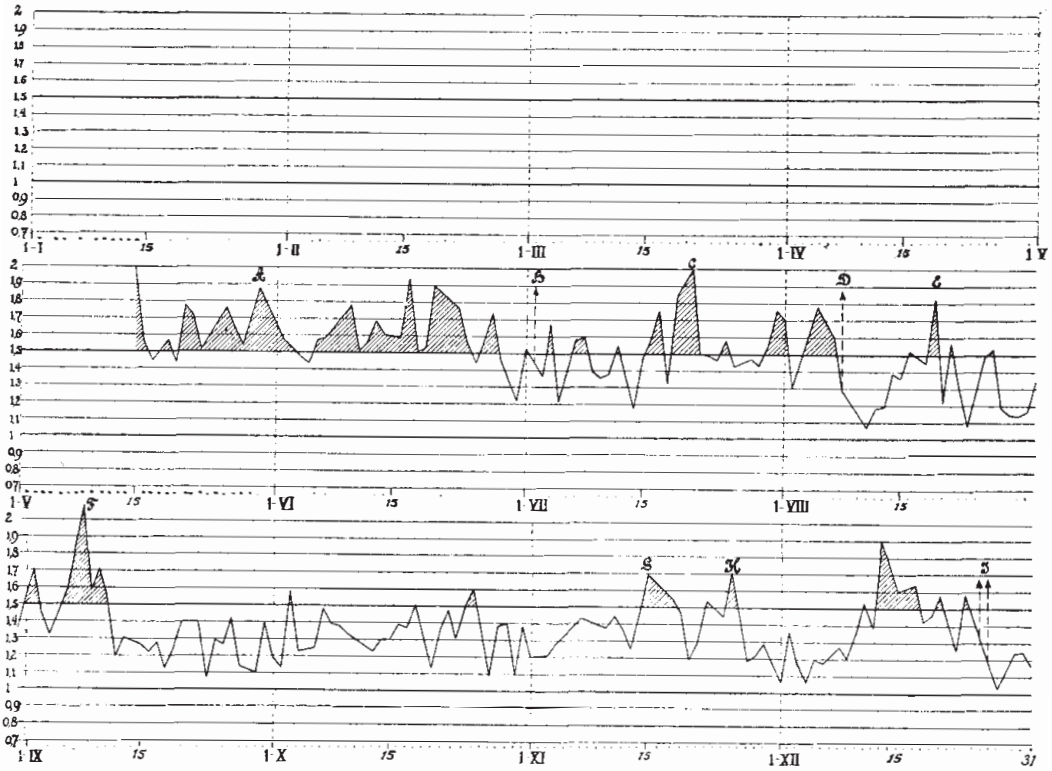


FIG. 1.—NUMBER OF FAULTY CONNECTIONS AS PERCENTAGE OF THE TOTAL NUMBER OF CALLS IN 1924.

(1st) Control faults which have given no cause for a complaint, yet have been found by the staff by means of tests, either by the routine tests or by various supervisory apparatus (C faults).

(2nd) Faults, which are reported by the public to the monitor (S faults).

(3rd) Faults, which are advised by the operators (B faults).

The first category affords an indication of the activity of the staff, while the figures of the second are a measure of the public's appreciation of the service and as such can serve as an indication of the quality of the service.

The third group stands more or less by itself. The faults

belonging thereto can belong either to the first or the second group: it is not always clear in which category they should be.

They naturally only appear in the semi-automatic exchanges and are only located in the apparatus which is used in connections completed by the telephonist.

Quantitatively they have not much significance. The sum of the three kinds of faults is a measure of the technical perfection of the whole apparatus. In conjunction with what has just been said, the staff in the exchange may be divided as follows:—

I. *Maintenance staff* (*C faults*).

II. *Fault staff* (*S and B faults*).

The first staff works on its own initiative; the second works when fault reports are handed in.

The maintenance staff includes the following:—

(*a*) Cleaning and tidying.
(*b*) Routine testing of switches.
(*c*) Inspection and revision.
(*d*) Control by means of supervisory signals.
(*e*) Control through fault statistics.

We shall discuss these in more detail.

III. *Cleaning Staff.*

Since the working of an automatic exchange depends so very largely upon many contacts of many sorts it is necessary to keep the rooms very free of dust.

Contact faults arise through burning, *i.e.*, electrolytic oxidation, or owing to the contact being dirty with dust.

In many cases the last stimulates both of the others, especially the second phenomenon. The dust floating in the room collects on the contacts, at first through the breathing of the relay, and, secondly, possibly collects through the electric charge of the contact points. The breathing arises through the heating and cooling of the relay coils, causing air currents to and from the relay casing.

These air currents bring dust with them or what is yet more annoying very fine particles of oily matter, arising from the lubricant, or paint and perspiration from the strongly heated coils.

The greater the number of relays which are enclosed in a relay group the stronger will be the phenomenon of breathing and the greater is the possibility of dust trouble. In a very short time the deposition of dust occurs on the inside of the relay covers. The results of the Amsterdam fault statistics show that a large number of contact faults appeared after 5 or 6 days of dust movement or dust activity. The running and still more the removal of cables, the visits of a great number of people, blowing dust from the I.D.F. and, most troublesome of all, painting with quick dry-

ing paint increase the number of faults. This can easily be seen from point L on the curve in Fig. **2.** As a result of the painting of the ceiling and of a wall in the Central Exchange, the faults rose shortly afterwards so much that the percentage of faulty connections reached 2.48%, 1.5% being normal.

Seeing that the phenomenon was well known, and also knowing which contacts were the most likely to suffer, the trouble was quickly removed.

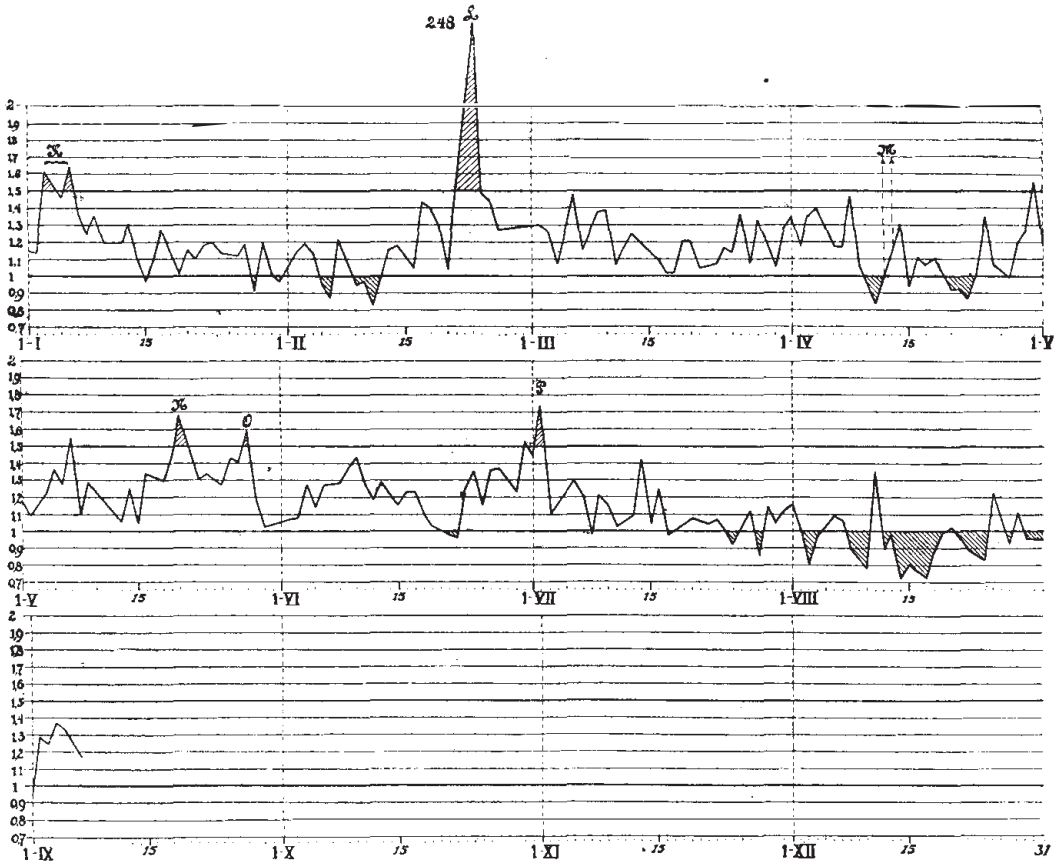


FIG. 2.—NUMBER OF FAULTY CONNECTIONS AS PERCENTAGE OF THE TOTAL NUMBER OF CALLS IN 1925.

The same thing happened shortly after the exchange " North " was opened, which occurred unfortunately simultaneously with a heavy overload. Here also painting had just previously been done. In this case the contacts chiefly affected were the break contacts of the cut-off relays and largely those which only carried speech currents; (among others, in the manual board selectors).

An improvement can be made here by so designing the trunking scheme that a small direct current is carried over the contact. The case is the same with the impulsing contacts of the motor interrupters. The contacts carrying direct current are not so sensitive to dust, but wear away sooner than the contacts which carry only speech and signal currents (A.C.).

It is necessary to keep the auto room as free of dust as possible. Cleaning of contacts which is necessary to prevent the occurrence of trouble if dust be present must be restricted as far as possible because of the wearing of the contacts, and because much re-adjustment of relays and switches would be necessary afterwards.

It is much better to avoid trouble by preventing dust in any feasible way. Regular cleaning of contacts occurs only now and then and less frequently on the contact banks of the Strowger switches.

The cleaning of the apparatus is restricted to the removal of dust from springs and relay covers (these also on the inner side) while simultaneously the dust displaced is removed by a powerful vacuum cleaner. For this cleaning, two workers are always needed, one controls the dusting brush and one controls the vacuum cleaner. Co-operation between the two is naturally required and needs effective supervision. A powerful vacuum cleaner is installed in the power room in each exchange, to which pipes are connected throughout the whole building. Portable hand blowers are also provided to blow away dust if necessary. These must not be used on switches. They only serve for the cleaning of the M.F. & I.D.F. and are always used in conjunction with the vacuum cleaner. Even with these careful measures it is found that after each time dust is blown away an increase of the number of contacts faults is noticeable. The distributing frames cannot, however, be cleaned in any other way.

To prevent the accumulation of dust, all auto rooms are provided with linoleum on the floors, which is always kept waxed to hold the dust. The rooms are approached through double doors, and the ventilation is done exclusively through ventilators, which draw air through openings covered with flannel filters. The humidity is of much importance. With great dryness, under 30%, there is an increase of dust. This is noticed during periods of hard frost when the heating must be effective, and the air is dry. It is then necessary in one way or another to introduce vapour with high humidity. Above 70%, insulation faults begin to be apparent. For these reasons the humidity is kept between 30% and 70% if possible. Considering that contact faults amount to 20—50% of the total number of faults advised by the public (S faults) it is obvious that the work taken to avoid these is quite justified.

A very great improvement in the number of contact faults has been brought about through the introduction of double silver contacts. The contact spring is split, and each contact consists of two contacts side by side, each with independent contact points.

The improvement brought about by this type of contact in the impulse sender relays in C.B.3 is apparent in the great decrease

in the percentage of ineffective connections, after the installation of double silver contacts. (See line D in Fig. 1).

The exchange East, C.B.5 is provided throughout with such contacts, which is evident from the number of contact faults.

The number of contact faults on the break contact of the cut-off relays (*t* contact) amounted to:

C.B.2	20%	of the total S faults	(with good inspection).
C.B.3	60%	,, ,,	,,
C.B.4	50%	,, ,,	,,
C.B.5	10%	,, ,,	(double silver contacts).

IV. *Routine testing.*

It is necessary to look for eventual faults and defects through the periodical control of the switching apparatus before they have given rise to faults during the working. The more energetically this control functions and the greater the percentage of total faults found in this way, the less will be the hindrance which the public will experience from unavoidable faults. Much routine testing needs a big staff, and a position is reached where increase of staff produces very slight improvement in reduction of C faults.

Too many examinations of the apparatus disturbs the working and reduces the number of switches available for the traffic. Naturally the less busy hours are chosen for routine testing.

The maintenance staff in Amsterdam works from 7 a.m. to 7 p.m.; outside these hours watchmen only are on duty. The testing of switching apparatus takes place mostly between 7 and 9 a.m., 12 to 3 p.m. and 5 to 7 p.m.

There are three kinds of tests:—

First, the functioning of the switches in all levels. For this purpose there are jacks in the connections to the switches.

The faultsman inserts a tester in a jack of the group selector and raises the selector one by one to all rows and lets it rotate.

In the case of the 1st group selectors the signals are observed at the same time. In the case of the final selectors the switch is directed to a control fault number to which the tester has been connected, to prove the working of the signals.

Usually all selectors are tested once a week in this way. Occasionally an extended test takes place, which consists in proving the outgoing trunks of a bank of each. All the contacts of any row are disconnected except one, while the group selectors of the following level are removed. The switch thus comes during rotation to a pre-determined contact, from which the trunks can be controlled. For these tests two men are always necessary and they take a long time. Nevertheless, it is always done when work has been done on the selectors or the preselectors.

Second. Testing switches which are not in the normal position.

This serves to show which switches do not switch out in use. The faultsmen supervise this by investigating with a head telephone the voltage condition of the lines, at the same time all idle switches are tested to see if they are connected to battery.

This test can be done very quickly by efficient men and is done each half hour when possible. It shows up a great many of the C faults.

Third. Making complete test calls. This is done through the traffic office, mainly with other objects, yet it may also be advantageous in the search after faults. The traffic office makes on certain days in the busiest hour a great number of test calls, say from 400 to 600, from numbers in groups with very heavy outgoing traffic, to numbers in groups with very heavy incoming traffic, and investigates in this way the possibility of connections during the most unfavourable hours and under the most unfavourable conditions.

The tests go over all levels and all trunks by varying the test numbers. If faults are then found the switches and lines used are, if possible, held and instantly reported to the relative auto room. The cause of the fault is sought for at once. The tests are made through a routine testing office, with carefully controlled testers, so as to ensure that the defects reported in the exchange will be sought. Owing to the great number of these tests and the variety of the channels used, these tests give an accurate view of what a subscriber should experience when working without error, with good instruments in the most unfavourable conditions.

For the full automatic exchange, the faults found in this way amounted all told to 0.2%; for the semi-automatic the faults were 3.5%, of which 1.5% were faulty numbers due to telephonists' errors, and 1.5% to the manual board switches.

The preselectors are given no regular tests except when there is a particular reason for it. To do the whole lot regularly would take too much time. The manual board selectors are routine tested about once a fortnight.

V. *Inspection and Supervision.*

An exchange is divided into 6 groups for maintenance: *i.e.*, five of 2000 lines (1st preselectors, 2nd preselectors, 1st group selectors, manual board selectors, 3rd selectors, and finals) and one group taking all second selectors. In the semi-automatic exchanges there is a seventh group comprising the impulse senders with the digit keys. In each group there are two mechanicians and an assistant, who are responsible for the working of

the group. They work as far as possible always in the same apparatus group, doing all works, for both tests, and the search for faults. They do the necessary inspection and supervision of the switches. The first consists chiefly in following the working of the selectors in use. They are so practised that to a great extent they work by hearing and recognise any abnormality by sound.

Supervision means the systematic control of the switches and relay groups, for the purpose of adjusting all subsidiary parts, following the adjustment details.

Formerly this supervision occurred periodically. At stated times the apparatus was withdrawn from service and tested for correct adjustment in a mounting on a bench equipped with special testing apparatus. This has usually proved unnecessary. At present the group switches and relay groups are only subjected to supervision when, on account of some kind of fault, they have been taken from their place for repair.

The switches are repaired in the room. The relay groups are repaired in a small work room, placed close to the auto room, where tools and parts are available and also a small test panel whereby the working of the relays and impulse senders can be tested in accordance with rules laid down.

This supervision and the simple repairs are done by the personnel of the group during the time when three men are present, so that two can work in the auto room and one in the workshop. This is normally between 10 a.m. and 4 p.m. See Fig. **4.** It will be seen that in this way the working of selectors comes under supervision, as follows:—

1st selectors, twice per year.
2nd selectors, once per year.
3rd selectors, once per two years.
Final selectors, once per year.

As all selectors are numbered and always stand in the same place, accurate records can be kept.

This gives good control over the quality of the apparatus and of the work of the maintenance men.

VI. *Control via Supervisory Signals.*

These are
(*a*) Blown main fuses.
(*b*) Blown distribution switch fuses.
(*c*) Late disconnection of interrupter.
(*d*) Congestion in groups when all available outlets to the following rank are busy. This is only for 1st and 2nd preselectors.
(*e*) Failure of signal interrupter, ringing current, etc.

(*f*) Permanent loops: this is given after 120 seconds.

(*g*) 1st group selectors, where a connection is called for, but does not come to fruition because the connection is broken in the first or following ranks, or through a disconnection in a level. The alarms (*a*) to (*e*) are denoted by various coloured lamps for each section and division of 2000 lines. *a* and *b* are also given audibly.

The signal *f* is a lamp for every row of 10 first group selectors. When it lights, the faultsman looks for the relative selector, connects his test set and finds if a subscriber is talking. These signals are mostly caused by short circuits outside the exchange, which are then discovered by this method.

(*g*) is the most significant alarm; it consists of a small lamp on every 1st group selector. There is, further, a supervisory signal per group, denoting in which thousand a signal *g* has appeared. These lamps are placed near jacks, through which the faultsman can enter the circuit. The signal appears as soon as the connection fails, and lasts as long as the subscriber concerned does not hang up.

The faultsmen in charge of a division during the busy hour remain near the 1st group selectors. As soon as a signal *g* appears, he butts in and seeks for the cause of the fault. The subscriber is sometimes to blame and he can be informed. Sometimes trouble is caused while all lines in the level asked for are busy.

In many cases, however, it is a fault which the faultsman can detect by taking the 1st group selector over from the subscriber, in the position to which it has been raised, and then demanding the same number as the subscriber has done. If this connection cannot be put through the switch can be held and the way in which the call has gone astray can be found and investigated.

A great number of C faults can be found in this way, which requires the continual surveillance of the faultsman. For the sake of completeness it should be mentioned that while the connection the faultsman makes may be successful yet this does not mean that no fault exists. The connection may have been made by another route. However, the faultsman is usually quick and therefore no change has occurred in the position of the succeeding selectors needed to complete the desired connection, and the second connection follows the same route as the first. If the fault be not found, he notes the called number and gives special

attention to the fact if more alarms *g* come from the same 1st group selector. Alarms *g* are multipled on a desk in the exchange Inspector's office. The working of the exchange can be judged from the incidence of the glowing of these lamps, and indicates whether his presence is required in the auto room.

VII. *Control by fault statistics.*

Fault statistics afford an indication of the standard of maintenance. In many cases they also serve directly as a means of investigating faults.

In the case of complicated switches, one cannot fully determine that they are fit for service by just testing them at the test table. When a switch fails to function properly five times out of 100 connections, it is not fit for service and yet it is quite possible that it had been found O.K. on test.

The impulse senders give a good example of this. When these are all in the same condition as regards maintenance, and the traffic is distributed well and evenly in the exchange, then for all senders the ratio of the number of ineffective calls to the total effective calls is the same, unless one of the senders has some small fault which brings it into an unfavourable situation as compared with the others.

When it is possible to calculate the proportion aimed at above for the whole of the impulse senders, which in Amsterdam can easily be done, then an average is obtained for any twenty-four hours, from which the individual figures of the switches may deviate but little.

As soon as an impulse sender shows deviations from the calculated average, which lie outside the limits of pure chance, it is switched out and again tested carefully in accordance with instructions. If it is brought back to its place the faults must vanish, which is generally the case.

Fig. 1 and Fig. 2 show clearly the result of working in these ways. The figures show the number of ineffective calls per 24 hours in C.B.3 as a percentage of the total number of calls for the period 15th May, 1924, to 1st September, 1925.

Between points B and D the improvement in impulse senders through the introduction of double silver contacts is apparent, because the figure falls regularly from an average of 1.4% to 1.0%.

The peaks have always some particular cause and as such are interesting.

These are to be imputed either to heavy traffic or to a junction breakdown, or to special circumstances.

The cause of the faults are given below; the letters refer to letters on the figure,

1924. A. Heavy traffic at Ascension Day.
B. Beginning of improvement in impulse senders.
C. Fault in junction cable C.B.2—C.B.3.
D. End of improvement in impulse senders.
E. Fault in junction cable C.B.3—C.B.5.
F. Heavy traffic in C.B.4.
G. Fault in cable C.B.3—C.B.2.
H. Heavy traffic in C.B.4.
J. Christmas.
1925. K. Heavy traffic in C.B.4.
L. Auto room painted. (See above under III.).
M. Heavy traffic before Easter.
N. ,, ,, ,, Ascension Day.
O. ,, ,, ,, Whitsuntide.
P. Two manual board selectors faulty.

It is clear that in these graphs abnormal occurrences are easily separated from the normal and their influence can be predetermined. Space does not allow me to go further into this.

A method similar to that described for the senders was applied to the first group selectors in the full automatic exchange: the proportion of connections which failed due to switch faults to the total number of connections per row of 10 switches for 24 hours were also calculated.

The effect of this system of control is much better than any other testing scheme and the resulting figures may be useful at some time for other purposes.

VIII. *Fault Staff.*

The fault staff has to clear as speedily as possible the faults which have been advised by the complaint office and found faulty by the Testing Operator. They are handled by the faultsmen in the relative group. The great majority of these faults are found in the apparatus particular to the lines, chiefly in the preselectors and in the final selectors.

The same procedure is followed in the case of faults advised by the operating telephonist in the semi-automatic exchange, which usually occur in the manual selectors, impulse senders, or digit keys.

Table II gives % faults in group C, S and B, and of the total T distributed among the various classes of apparatus. The figures for each exchange per month are fairly constant, as can be seen from Fig. 3, though they vary slightly round the average. Also for the various exchanges, they do not vary much from one another unless special reasons exist.

For example for C.B.5 the figures for preselectors are low as

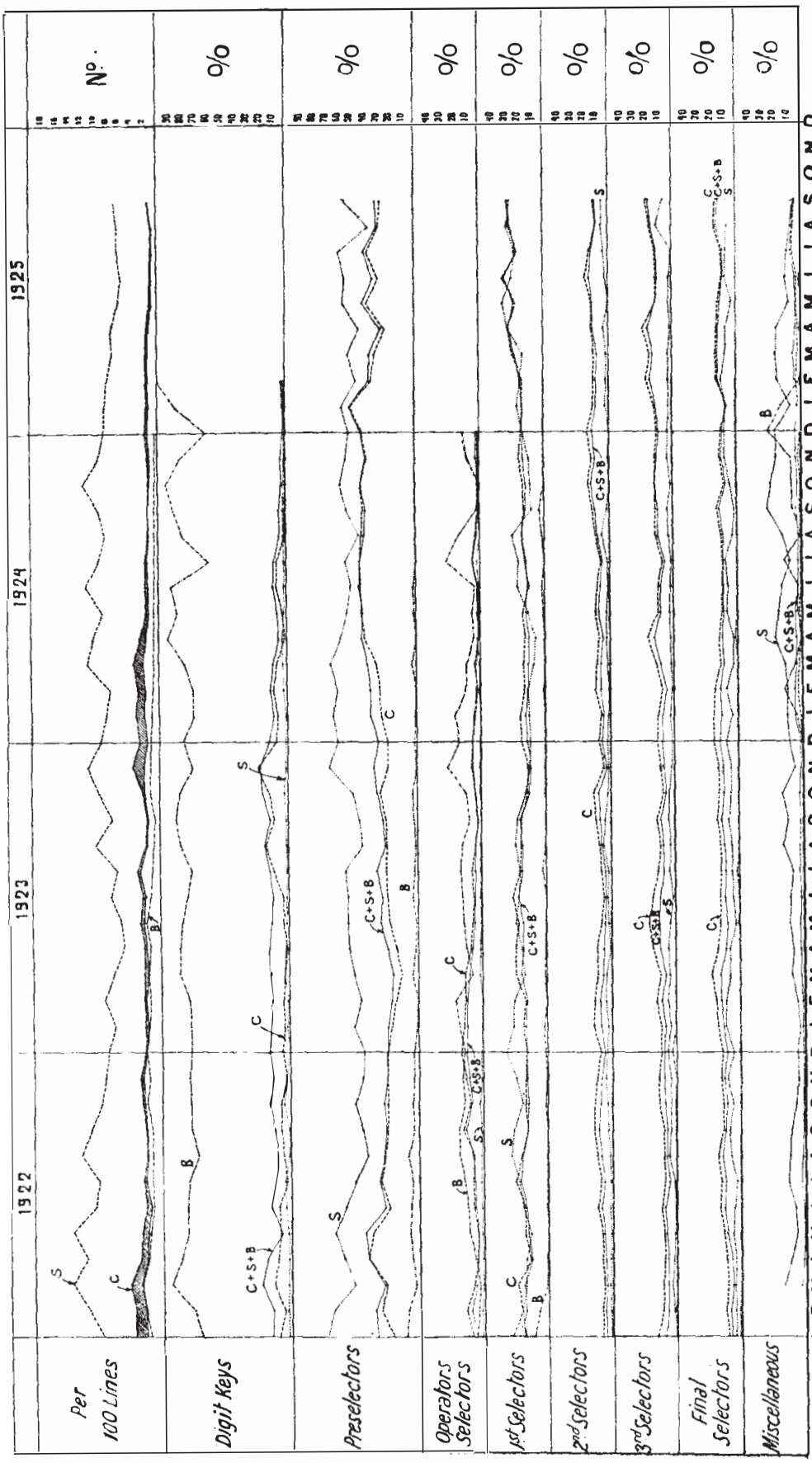


FIG. 3.—FAULT STATISTICS FOR EXCHANGE C.B.2.

a result of the double silver contacts; for the 1st group selectors they are high because there an impulse repeater is concerned which in other cases is wanting. From Table III we see further the distribution of faults among C, S and B: 70—90% were found by the patrol. The high figure for C faults for C.B.5 may be explained through the improved preselector contacts which cause the greatest part of S faults in other exchanges.

It is easy to see that the full automatic exchanges have fewer faults than the semi-automatic. The cause lies in the manual board selectors as appears from Tables II and IV. C.B.3 suffers most; it is the only exchange where the manual board selectors are provided with self interrupters. Fortunately they will disappear after cut-over to the full automatic system.

In conclusion, Table IV shows the proportion of C and S faults in % for each type of switching apparatus, likewise the number of faults per 100 switches per month, calculated from an average over the first 9 months of 1925. The figures for the various exchanges do not vary much from one another and nearly all deviations lie in small differences in the build of the installations. Space does not allow me to go deeper into the question.

IX. *Graphical statistics.*

The best way of watching the maintenance in an automatic exchange is to have appropriate statistics; and the most easily understood are graphs. Each individual exchange can be watched and the results compared with those of all the exchanges. Standards for the various quantities are first obtained. For unfavourable deviations one can find explanations, in order to find how to prevent these occurring.

If the deviations are in the favourable direction one can investigate these to see if the standard can be improved.

In Amsterdam 7 graphs are kept permanently of each of the various types of apparatus in the exchange, *i.e.*, for preselectors, 1st selectors, 2nd selectors, 3rd selectors, final selectors, manual board selectors, digit keys: and for a miscellaneous group not included in the others.

The seven graphs are:—

(1) C faults per 100 switches per month.
(2) S ,, ,, ,, ,, ,,
(3) B ,, ,, ,, ,, ,,
(4) % of the total number of C faults.
(5) ,, ,, ,, S ,,
(6) ,, ,, ,, B ,,
(7) % of the total number of (C + S + B) faults per month.

There were also deduced graphs for

(8) the number of C faults per 100 lines per month.
(9) ,, S ,, ,, ,, ,,
(10) ,, B ,, ,, ,, ,,

The term, number of switches and lines means the working number, not the capacity.

In full automatic exchanges 3, 6, 10 do not appear. Graphs 1, 2, 3; 4, 5, 6, 7; 8, 9, 10, are connected so that the total can conveniently be found. In Fig. **3** the graphs 4, 5, 6, 7, for all types of apparatus are shown for C.B.2, also 8, 9, 10 are indicated for the years 1922-1925. It is seen from the figures how far the quantities are constant, and thus can be considered as standard. Between Feb. 1924 and March 1925, C.B.2 was changed from semi to full-automatic. The effect can be studied on the graphs.

The fall in the number of S faults for 100 lines is noticeable.

The lines 4 show how the control has worked in the previous month and which part of the equipment has been given special attention; so one sees for example from line 4 of the preselectors that in March, 1924, more attention has been given to these. The result is visible in the fall of the line 2 and the rise of 1 (not given in Fig. **3**) relative to the preselectors and similarly through the falling of line 9 without 8 rising appreciably. This is actually the case. After the more intensive control is continued for some time, the lines 1, 2, 8, and 9 all reach a lower level, to which line 4 also approaches, as otherwise the other apparatus would come too far behind. Usually the lines 4 to 7 give results for the equilibrium, that is to say, for a judicious distribution of the maintenance work on the various types of apparatus. The others show more the resultant of the activity. The falling of line 1 with a rise of line 2 and conversely show the transfer of emphasis laid by the maintenance staff on various types, while the same phenomenon appears in lines 4 and 5. If this is not the case, there must be external causes for the discrepancy and these must be sought for. Probably all or at least many of the lines 1 and 2 show the same phenomenon.

Simultaneous rises in lines 1 and 2 have always an external cause, which lies beyond the scope of the maintenance men. Usually any sudden rise in one of the lines is followed by a fall and conversely. With the help of graphs one is always in a position to study the effect of such influences on the other apparatus. The data for these graphs were obtained as follows: Any fault or deviation is written down on a docket by the faultsman who handles the fault.

These dockets are collected on cards and once a month added up and put in graphical form. On the cards the statistics are

given in detail, so that it is always possible to analyse further a portion and see the relation to the three categories of faults. This is done as soon as the lines show abnormalities.

The faults are divided into electrical and mechanical faults; these are again subdivided into the groups where they occurred and according to the type of fault observed. These figures are, however, by no means constant.

Sometimes special statistics are taken over selected portions which require investigation. Yet all these activities are secondary, so long as the above mentioned lines are normal. Detailed studies are only undertaken when the graphs give cause for such. It will be noticed from Fig. 3 that the lines are fairly independent of the seasons and also, within definite limits, of the traffic. The last holds also for various exchanges as regards lines 1—7, while the average load per switch in the exchange is the same, which is always the case if the design is good.

The lines 8 to 10 for an exchange with heavy traffic per line naturally lie higher because more switches per line are in use.

In the same exchange, the number of faults is independent of the traffic within certain limits, so long as the normal load on the switches is not exceeded and thus not many calls are lost. When that occurs the faults rise quickly and as soon as the critical point is reached they rise so fast that serious congestion is to be feared. The critical point lies somewhat higher than the capacity of that group of apparatus, which has the smallest capacity as compared with the traffic.

In a well designed exchange the traffic capacities of the various groups of apparatus are about the same. The critical point in C.B.4 lies about 23000 calls per hour. For the impulse senders the conditions are different in some ways. The number of faults in these is proportional to the square of the number of connections; happily the curve of this function is very flat for normal loads.

The difference as compared with the switches is easy to understand. The impulse senders function as long as they are in use and on the average always for the same period which is independent of the traffic. The switches operate, however, only at the beginning and the end of the connection and whenever, as a result of congestion, the average duration of the connection becomes smaller, then the number of times that it is actually in active operation during a definite time begins to increase appreciably.

From that moment the number of faults increases as the square of the traffic, and rises very steeply in the neighbourhood of the critical point.

X. *Staff.*

In the various competitive comparisons between systems, the maintenance staff has always played a significant role. One must here be very careful in judging the figures, because the amount of staff required does not exclusively, nor even principally depend upon the system.

There are other factors which have great influence. These can be described as :—

A. The traffic per line and the size of the telephone system in which the exchange works.
B. The limits set to the quality of maintenance.
C. Service conditions and regulations concerning working hours of staff.
D. The installation and the building of the exchange.
E. The system.

A. The greater the traffic per line so much the greater is the number of switches, and thus the greater the number of faults for an exchange of the same number of lines. In a great network with a lot of junction traffic the second selectors form such a large group that they need special supervision and more maintenance.

Whenever one compares a simple exchange with one of such a system both these factors must be remembered.

B. When a good standard of maintenance has been reached in an exchange, improvement only occurs by increasing the number of C faults and a reduction in the S and B faults. One can be satisfied with 70% in the first category and yet can wish for 90%. The latter necessitates more work and therefore more staff.

Besides this more emphasis can be put on cleanliness in the exchange and the demands for routine testing can be reduced. The influence of this on the number of faults has already been referred to in Fig. 3.

How far must one go with maintenance?

In the first place until a reasonable minimum has been reached for the total number of faults C + S + B. Then one may strive to reduce the percentage of C faults at the cost of the S faults, so long as the result obtained is relatively greater than the increase in cost.

Whenever, for example, it costs 20% more manhours to obtain a reduction of 1/10th in C faults, the limit has been passed.

There is also, however, another limit. Whenever the total of S faults in the exchange has become too small, so that it has no marked influence upon the total number of faults in the network then the improvement in the proportion of C faults to S faults is useless, as it does not pay for itself.

It is no matter that different ideas exist as to the grade of

perfection of the maintenance which influence the number of staff considered necessary, and which have nothing to do with the system as such.

As an example one might mention that in Amsterdam none of the exchanges is allowed ever to be unattended, not even at night.

This avoidance of risk may have great influence upon the number of the personnel; above all in connection with what is said below in paragraph C.

C. This factor is one of the most important.

The prescribed hours of labour, rest times, Sunday and night work, the possibility of overtime, the limits within which the work hours must be kept, all these factors influence the formation of staff in the exchange.

If one has several exchanges of dissimilar size in one area then the burdens laid upon the staff in one exchange must not differ much from the burdens in any other, which leads to an overstaffing of the smaller exchanges. Otherwise the frequency of the night and Sunday work would become too great.

One can overcome this disadvantage to some degree by moving the staff from exchange to exchange, but this creates difficulties, above all if the exchanges are not all on the same system.

D. That the nature of the installation and type of exchange has influence upon the staff is obvious.

To have many small rooms for the plant is obviously more disadvantageous than to have large rooms. If the switches of the various groups are scattered irregularly, naturally more staff is required than with a rational layout.

E. The system itself naturally has a bearing on the case. Wear, accessibility of the parts, interchangeability, the necessary number of switches and their form, the tools, overloading, these have all influence on the staff required though not to the extent one might ordinarily assume.

In conclusion, one should consider the type and age of an exchange. For example, consider the exchange with sequence switches (minor switch type) which undoubtedly requires more maintenance than one without the continuous drive, and yet there are very good reasons for keeping this type in use. One thinks among other things of the advantage of similarity.

For the sake of completeness Fig. 4 gives a scheme of the normal staff in a fully equipped automatic exchange of 10,000 subscribers at Amsterdam, from which one sees the distribution of the hours of labour.

There are two groups of mechanicians, each with a foreman, one group of helpers, and one group of cleaners, unskilled workers. During the hours when both groups of mechanicians are present,

one is working in the workshop, with the exception of the mechanician who is on evening duty.

In order to even out the service staff the exchange is divided up into six groups, five of 2000 subscribers and one group of 2nd group selectors. For each of these there are two mechanicians and a helper, while two extra helpers are provided for making up the complement of staff in the evening and at night.

The group of cleaners consists of six men, who work wherever they are required in the exchange. The total staff consists of 22 maintenance men and six unskilled workers, as appears from Fig. **4.**

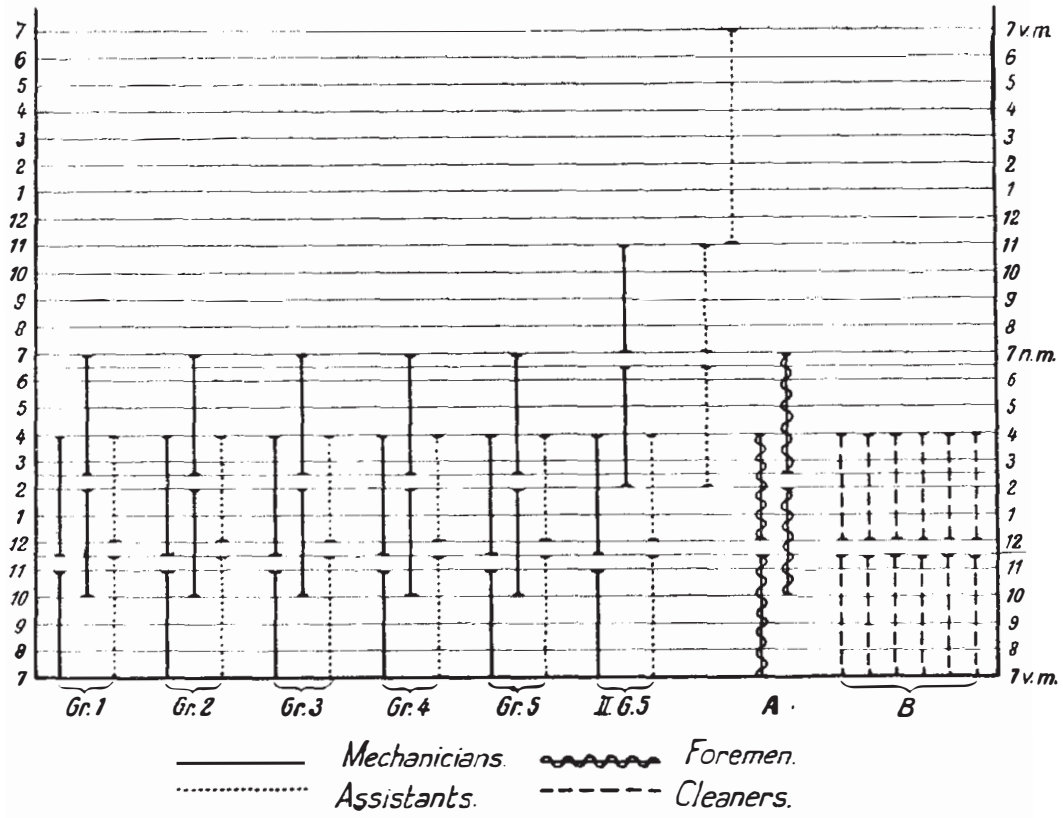


FIG. **4.**—NORMAL STAFF IN 10,000 LINE AUTOMATIC EXCHANGE.

One must look at this scheme in the light of what has gone before, and not consider it as the only one, or as the best for the normal case. It has been evolved for the specific Amsterdam case and requirements. Apart from and alongside of the maintenance staff of the exchange, there is a group of erectors. These are used for the installation of modifications, small extensions, large repairs and if necessary are available for assistance of the exchange staff in the case of long sicknesses and similar absences of several maintenance men. Service in this group is at the present time the practical opening for new staff.

TABLE I.

VARIOUS FIGURES.

Item.	C.B.2.	C.B.3.	C.B.4.	C.B.5.	C.B.6.	Total.
1. Number 1st Pre-selectors ...	10,000	8,000	10,000	4,000	1,000	33,000
2. Number 2nd Pre-selectors ...	1,000	800	1,000	400	100	3,300
3. 1st Group Selectors	600	560	700	240	60	2,160
4. 2nd Group Selectors.						
Trunk ...	340	350	450	120		
Junction ...	360	400	600	240		
Total ...	700	750	1,050	360	100	2,960
5. No. of 3rd Group Selectors ...	700	560	900	280	80	2,520
6. Final Selectors...	1,000	1,120	1,400	410	120	4,050
7. Total Switches...	14,000	11,790	15,050	5,690	1,460	47,990
8. No. of lines, 1 Sept., 1925.						
Normal ...	v. 8383	h. 3,034 v. 2,130 5,164	h. 7,210	v. 3,121	v. 328	24,206
P.B.X. ...	v. 73	h. 161 v. 93 254	h. 321	v. 54	v. 57	759
Incoming only	v. 26	h. 111 v. 41 152	h. 233	v. 16	v. 18	445
Outgoing only	v. 11	h. 47 v. 18 65	h. 85	v. 12	—	173
Total ...	8493	5,635	7,849	3,205	403	25,583
9. Max. hourly calls Jan., 1925.		h. 9,836 v. 3,480	19,950	5,593	726 July '25	50,621
(Peak load) ...	11,436	13,316				
10. Average hourly calls, Jan., 1925.	10,749	12,224	17,367	4,917	611 July '25	45,868
11. Year of opening (1)	1911	1922	1923	1924	1925	
(2)	1919					

h. = halfautom = semi-automatic.
v. = volautom = full automatic.

Table II.

DISTRIBUTION OF THE TOTAL NUMBER OF FAULTS IN THE 3 GROUPS:—CONTROL-MONITOR = S; MANUAL BOARD = B. IN % PER TYPE OF SWITCH.

Type.	C.B.2.				C.B.3.				C.B.4.				C.B.5.			
	C.	S.	B.	T.	C.	S.	B.	T.	C.	S.	B.	T.	C.	S.	B.	T.
Preselector	32.8	53.4	—	36.0	9	40	—	15.8	4.7	53.9	—	15.1	13.4	24.7	—	14.4
1st Selector	23.6	24.2	—	23.2	18	20	—	17.5	23.8	13.2	—	21.5	36.4	38.2	—	36.6
2nd ,, ...	12.5	3.2	—	11.2	15	2	—	12.7	21.1	4.3	—	17.6	16.9	7.0	—	16.4
3rd ,, ...	16.3	3.5	—	14.4	13	4	—	11.3	20.2	4.8	—	17.1	12.6	15.9	—	12.7
Final ,, ...	13.5	8.6	—	12.7	25	12	—	23.5	23.6	8.1	—	20.2	20.2	8.9	—	19.0
Manual Bd. Selector...	—	—	—	—	15	2	30	12.7	3.3	0.5	24	25	—	—	—	—
Digit keys	—	—	—	—	—	—	70	3.8	1.0	—	75	0.7	—	—	—	—
Miscellaneous ...	1.9	7.0	—	2.5	5	20	—	2.7	2.3	15.2	—	5.1	0.5	5.3	—	0.9

TABLE III.

AVERAGE NUMBER OF FAULTS PER 100 LINES PER MONTH IN 1925.

Group	C.B.2.		C.B.3.		C.B.4.		C.B.5.	
		%		%		%		%
Control	6.84	84.2	8.9	71.5	7.96	72	6.9	93.2
Monitor	1.28	15.8	2.94	23.3	2.01	18	0.5	6.8
Manual Board ...	—	—	0.66	5.2	1.11	10	—	—
	8.12	100	12.50	100	11.08	100	7.4	100

TABLE IV.

AVERAGE NUMBER OF FAULTS PER 100 SWITCHES PER MONTH IN 1925.

	C.B.2.					C.B.3.					C.B.4.					C.B.5.				
	C.	%	S.	%	Total	C.	%	S.	%	Total	C.	%	S.	%	Total	C.	%	S.	%	Total
Preselector	1.97	77	0.6	23	2.57	.66	40	1.04	60	1.7	0.5	33	1.0	67	1.5	0.6	87	0.1	13	0.75
1st Selector	21.7	85	4.0	15	25.7	15.0	71	6.0	29	21.0	21.9	89	2.7	11	24.6	32.0	79	3.0	21	35.0
2nd ,,	10.2	95.3	0.5	4.7	10.7	11.1	96	0.6	4	11.7	14.1	96	0.6	4	14.7	10.	96	0.37	4	10.37
3rd ,,	13.1	95.5	0.5	4.4	13.7	12.1	90	1.4	10	13.5	13.5	96	0.5	4	14.0	9.5	97	0.3	2	9.9
Final ,,	7.7	90	0.9	10	8.6	13.7	85	2.4	15	16.1	10.6	94	0.7	6	11.3	10.5	96	0.4	4	10.9
Manual Bd.*	—	—	—	—	—	17.0	82.5	3.6	17.5	20.6	3	50	3	50	6	—	—	—	—	—

* Faults are advised by the operators.

TIME SAVING TESTERS FOR AUTOMATIC EXCHANGES.

By W. PRICKETT and H. S. SMITH.

Engineer-in-Chief's Office.

THE introduction of devices which effect labour saving to the extent of over 80% is regarded in the commercial world as a considerable gain, but the development by the Department of automatic methods of testing, as compared with manual methods, showed that this figure could be increased to over 90%.

Experience has proved that the former figure was easily reached by using tester " A " (described in the last issue of the Journal) for line switch tests in automatic exchanges. Tester " A," however, although testing automatically each outlet from a lineswitch, required the attention of a testing officer in order to make connection in turn to each of the subscriber's equipments to be tested. Tester No. 56, now to be described, obviates this necessity and makes the transfer automatically to the next line when the tests on the previous one have been satisfactorily completed. This process applies to the whole of the lines available on the multiple on a subscriber's unit, *i.e.*, 100. The testing officer's attention is required only for the commencement of the tests on the first line and for the removal of the tester to the next unit when the last line has been tested. He is thus able to proceed with other duties and need only attend to the tester in the event of its stoppage indicating a fault. The actual time occupied by the tester, in completing the 5000 tests required on a unit equipped with 100 line switches, is 50 minutes.

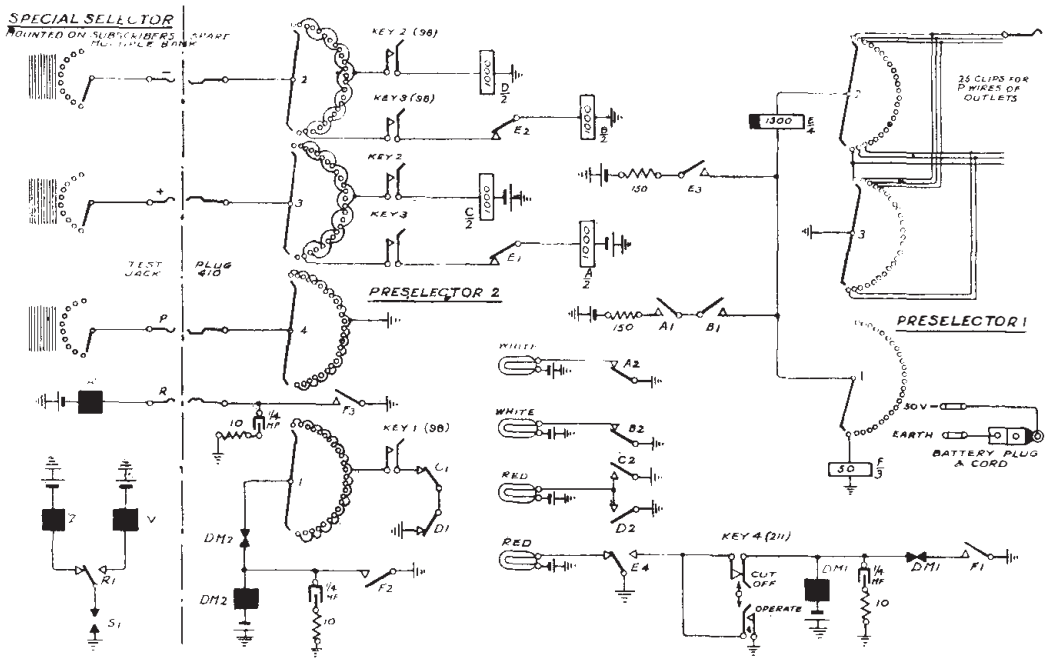
Tester No. 56.—For Testing Line Switches (non-homing) type) and associated Outlets to Selectors.

Tester No. 56 consists of two parts—the testing apparatus itself and a special selector. The latter is mounetd as required on a spare bank on the multiple side of a subscriber's unit and is used to make connection to each subscriber's line in turn. The testing apparatus includes two preselectors, one of which acts in a similar manner to that in Tester " A." The other is used to make the appropriate connections to the line connected by the special selector.

It is required to verify that the wiring and operation of the subscriber's line switches and associated outlets to selectors are in order. The tester, the connections of which are shown in the diagram, is designed to test each outlet twice in order to use each end of the double wipers with which the line switches are equipped.

Before commencing the test it should be verified that all equipped line switches are connected by means of straight jumpers to corresponding numbers on the multiple.

To commence the test, the special selector is mounted on a spare multiple bank and its wipers set to the normal position, which is special to this switch, on contacts 1 of level 1. The selector is connected to the tester by means of a test plug, and battery and earth are supplied *via* the usual contacts on the switch jack. The twenty-five clips provided for the purpose are connected, in order, to the P wires of the outlets on the terminal assembly on the line switch side of the unit.



CONNECTIONS OF TESTER No. 56.

Battery and earth for the tester are obtained *via* a cord and plug and the unit power jack.

All line switches and the tester preselectors should now be set to contacts 1.

Keys 2, 3 and 1 are then thrown in this order.

The effect of key 1 is to step on preselector 2 to contact 2. The circuit is from battery *via* DM2, interrupter springs, wiper 1 contact 1 of arc 1, key 1 op., C1 nor and D1 nor to earth.

Key 2 connects relays C and D *via* contacts 2 of arcs 3 and 2 to the + and − lines in order to provide a test for faulty operation or failure of the line switch cut-off relay (BCO). The latter should be operated *via* contacts 1 and 2 and wiper 4 of preselector 2. If the BCO relay has operated correctly, the + and −

lines will now be clear and relays C and D should not operate, thus allowing preselector 2 to step to contacts 3 as before. If, however, either the line relay or earth has not been disconnected by the cut-off relay, relay C or D operates and prevents rotation from contacts 2.

Relays A and B are connected by key 3 to contacts 3 of arcs 3 and 2, and when preselector 2 reaches these contacts are extended by wipers 3 and 2 to the line circuit. The BCO relay is released when wiper 4 reaches contact 3 and allows the line relay and earth to be restored to the line circuit. If there be no reversal in the lines, relays A and B and the line relay now operate. The line relay should cause the line switch to seize the first outlet and extend the line circuit to the selector connected thereon, relays A and B in the latter being operated, causing a guarding earth to be placed on the private wire.

The operation of relays A and B connected battery *via* a 150 ohm resistance at A1 op. and B1 op. to relay E. Relay E operates *via* wiper 2 and contact 1, arc 2 of preselector 1 to the earth on the outlet P wire. As, however, relay E is slow to operate, time is allowed (1) to ensure that the operation of relays A and B is maintained by the selector A relay being connected, without reversal, *via* the outlet and (2) for the line switch line relay to release, ensuring that the earth on the private is that supplied by the selector.

Relay E, operating, provides a holding circuit for itself at E3 op. and disconnects relays A and B at E1 op. and E2 op. to release the selector and cause the holding earth to be removed from the private. It also energises DM1 at E4 op.

Provided that the line switch line relay is not sticking, so maintaining the earth on the P wire, relay E should in due course release and, disconnecting DM1 at E4 nor., causes preselector 1 to step on to contacts 2, in which position wiper 3 busies the P wire of outlet 1 against further use.

The tests are now repeated on the line switch, but as outlet is busy, the wipers should be rotated to outlet 2, which should be seized. As relay E is now connected to the P wire of this outlet *via* contact 2 of arc 2, the sequence of operations should be repeated and if the outlet be O.K., it will in turn be busied and the test transferred to outlet 3.

This process is repeated until each outlet has been tested twice, *i.e.*, with each end of the double wipers.

When the fiftieth test is being made, relay F is connected *via* contact 25 of arc 1 and, on the operation of relay E, receives sufficient current to operate.

Relay F steps-on preselectors 1 and 2 *via* F1 op. and F2 op. and the special selector *via* F3 op.

The latter now makes connection to the second line switch to be tested and the sequence of operations is repeated.

This process continues until the tests have been completed on the tenth line, when the ensuing rotary step of the special selector operates the cam springs S1, energising the vertical magnet *via* R1 op. This causes the selector to step up to level 2 and then, on the release of the rotary magnet, springs R1 return to normal and the release magnet receives an impulse and releases the rotary dog, which allows the wipers to rotate back to contacts 1. Connection is now made to line 21 and the tests proceed as before.

This action is repeated on each level of the subscriber's multiple until the whole of the line switches equipped on the unit have been tested, when the tester comes to rest with the wipers of the special switch above the bank.

The special selector and tester connections are then transferred to the next unit to be tested and so on throughout the exchange.

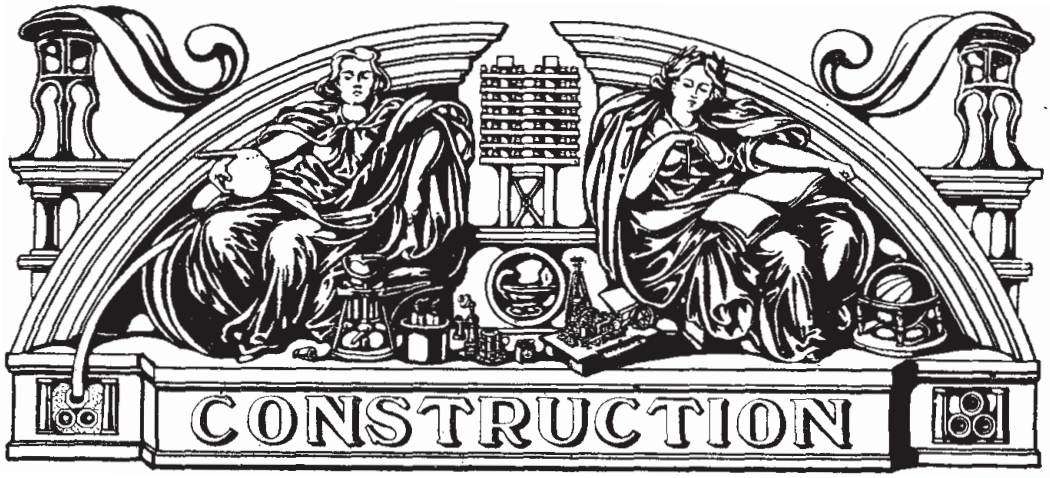
In cases where units are not completely equipped with line switches, the tester will stop when an unequipped line is encountered and the special selector is stepped on by hand to the next equipped line.

Attention is drawn to faulty lines by the tester ceasing to work and an indicating lamp glows to provide a rough indication of the nature of the fault. Thus, faulty operation of the cut-off relay causes a red lamp to glow, while trouble on the + or − lines is indicated by white lamps, and failure on the outlet by another red lamp. The application of these lamp signals is similar to that indicated in the schedule given at the conclusion of the previous article on Tester "A."

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE, IN EACH ENGINEERING DISTRICT AS AT MARCH 31ST, 1926.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
485,927	582	4,171	54,469	490	London	23,353	55,572	1,658,106	55,883
59,221	1,907	20,916	58,812	1,646	S. East	3,793	24,230	107,717	17,006
63,093	4,463	26,775	47,063	1,914	S. West	13,802	6,553	96,553	28,348
49,381	8,585	31,546	43,483	5,014	Eastern	12,868	27,176	58,837	52,139
81,855	8,448	41,986	52,798	3,455	N. Mid.	20,404	38,681	148,623	110,907
59,919	4,912	26,917	59,166	4,127	S. Mid.	12,384	17,358	114,574	83,432
53,042	5,015	28,405	46,276	2,206	S. Wales	5,274	20,408	86,556	69,492
85,143	8,010	24,555	44,627	5,271	N. Wales	12,318	35,811	171,337	48,929
133,440	1,608	17,031	45,111	3,071	S. Lancs.	12,527	69,011	363,842	37,995
79,963	6,009	30,423	42,660	2,973	N. East	9,391	35,311	178,669	29,479
53,848	3,650	24,235	36,074	2,452	N. West	8,301	30,856	106,953	32,094
40,836	2,367	15,758	24,321	2,134	North	4,167	9,389	73,019	46,907
18,800	4,808	6,214	11,950	262	Ireland N.	140	233	31,241	16
55,579	5,413	23,077	33,808	1,169	Scot. East	2,635	8,055	102,731	37,518
76,337	7,451	23,729	40,247	849	Scot. West	12,264	22,315	190,727	26,831
1,396,384	73,228	345,738	640,865	37,033	Totals.	153,621	400,959	3,489,485	676,976
1,365,643	73,993	341,118	632,959	35,885	Figures on 31st Dec., 1925.	149,290	384,434	3,386,045	615,026



A NEW TYPE OF FUSE MOUNTING FOR THE TERMINATION OF TRUNK, JUNCTION AND TELEGRAPH CIRCUITS.

A. O. Gibbon, M.I.E.E.

A high standard of insulation resistance is required by the British Post Office in connection with all underground cables used for telephone and telegraph purposes, and this is particularly the case where loaded and balanced Trunk cables are concerned. Great difficulty has been experienced in the past in obtaining the same degree of insulation resistance at the terminations of these cables at Main Distribution Frames, and also at testing points.

In the case of loaded and balanced Trunk cables it has been the practice to terminate the cables on an auxiliary testing fitting known as a "Trunk Testing Tablet." This fitting is made of "A" quality ebonite, and is of the "U" Link pattern, accommodating 18 circuits per tablet. The Test Tablet provides for a high standard of insulation, and also affords a ready means for the interception of circuits for testing and cross-connecting purposes. There are, however, certain disadvantages associated with the Test Tablet. It requires a special frame for mounting purposes and the complete installation takes up a fair amount of space; the Test Tablet is also exposed to the air, and loss of insulation follows because of the presence of moisture and also the accumulation of dust on the fitting.

For the termination of Trunk cables which are not loaded and balanced, also in terminating Junction cables, a fitting known as "Fuse Mounting No. 4001" has been used. This fitting has a

Sheet Iron base, and is fixed to the Main Distribution Frame. It suffers from the same disadvantage as the Trunk Test Tablet in that it is exposed to the air, whilst, in addition, the 4001 fitting does not provide facilities for the periodical routine testing of circuits from the Main Frame.

The design of a compact terminating arrangement which will provide for a high standard of insulation resistance has been under investigation for some time and, after a series of experiments with different models, the Standard Telephones and Cables, Ltd., have recently patented a special Fuse Mounting on the

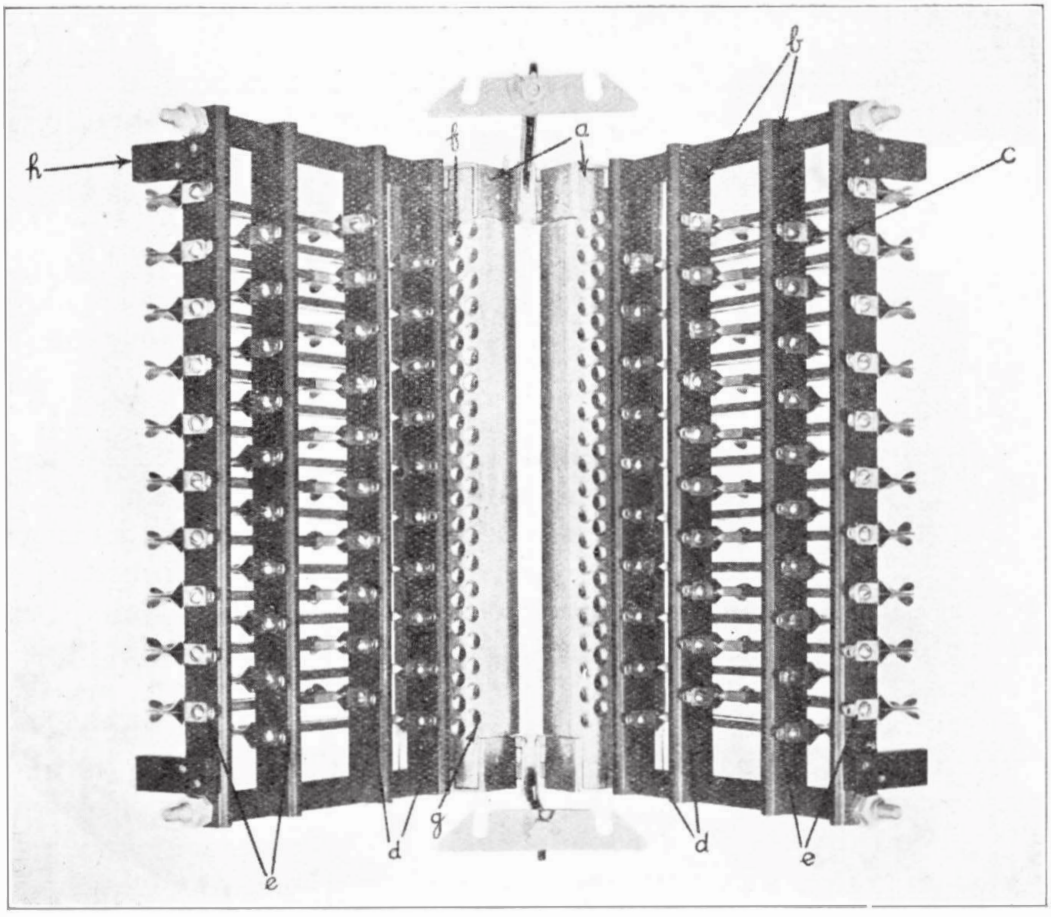


FIG. 1. FUSE MOUNTING No. 4028.

"Grid-Gate" principle. This mounting has been designed with the following objects in view:—

(1) To provide a high degree of insulation resistance comparable with that of the cable itself.

(2) To provide a ready means of testing and cross-connecting circuits, both on the line and Exchange sides of cable.

(3) To protect the fitting from insulation losses due to moisture and dust, and also to prevent mechanical injury.

The new fitting is known as "Fuse Mounting No. 4028." It is of approximately the same dimensions as Fuse Mounting No. 4001, with which it is interchangeable on Main Distribution

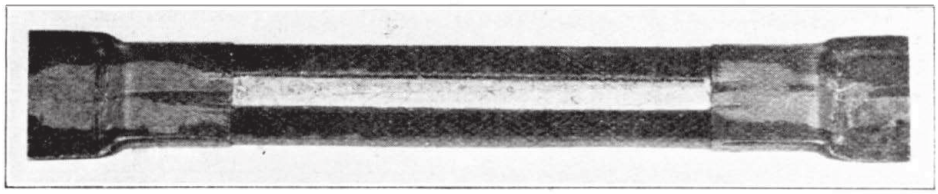


FIG. 2.—FUSE USED ON FUSE MOUNTING NO. 4028.

Frames. The mounting accommodates 20 pairs of wires on the line and apparatus sides and is a compact fitting. Tests for insulation resistance have yielded results in the region of 30,000 megohms between adjacent tags.

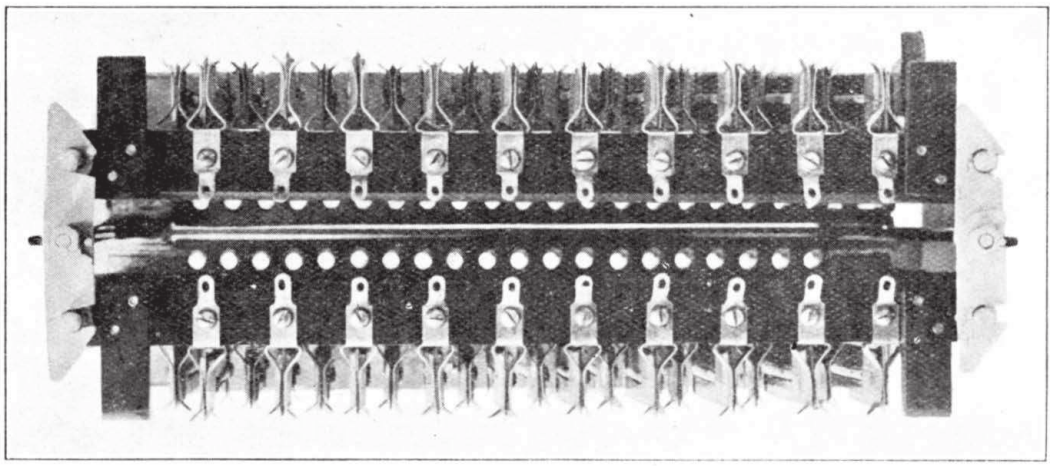


FIG. 3.—FRONT CLOSED VIEW OF MOUNTING. SHOWN HORIZONTALLY.

The mounting is made up in the form of a double hinged gate; Fig. 1 shows the fitting in the open position.

Two vertical wooden fanning strips marked "*a*" in Fig. 1 are fixed to the base of the mounting. Between these strips and hinged to them is a metal plate, or lug, which is shaped and bored for fixing to the Main Frame. This is shown clearly in Fig. 5.

A grid or gate consisting of four vertical ebonite strips is attached to each of the fanning strips, as shown in Fig. 1. (Two of these strips are marked "*b*" in Fig. 1). Fuse-holders are clamped to the outside of the ebonite strips, and the soldering tags are continued to the inside of the fitting, where all the wiring is done. The fuse holders and tags are shown at "*c*" in Fig. 1. Knife-blade fuses are fixed to the outside of the fitting.

It will thus be seen from Fig. 1 that all the wiring connections are made inside the fitting, and all testing operations carried out from the outside.

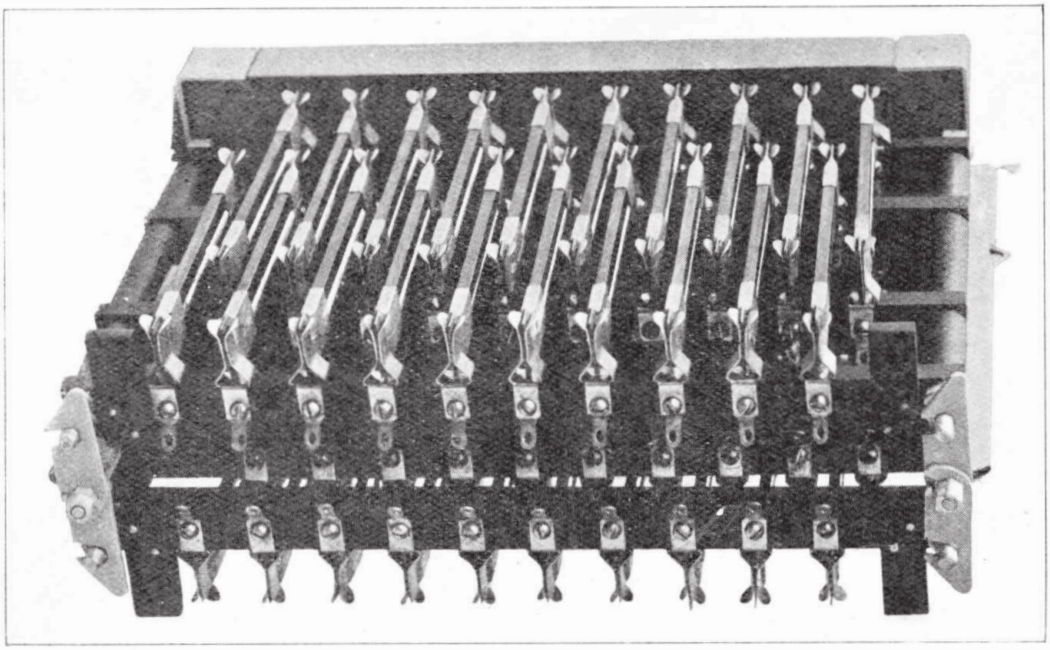


FIG. 4.—SIDE CLOSED VIEW. SHOWN HORIZONTALLY.

Each of the fanning strips is bored with 40 holes, 20 holes for the cable pairs, and 20 for the wiring on the apparatus side. The two vertical strips of tags on each side nearest to the fanning strip are used for terminating the cable conductors (See "*d*," Fig. 1), the outside two vertical strips of tags being used for the wiring on the apparatus side. This is shown at "*e*" in Fig. 1.

The holes adjacent to the vertical ebonite strips on each side are used for the cable conductors, the A and B wires following consecutively from top to bottom. See "*f*," Fig. 1. The two rows of holes nearest the metal plate, between the two fanning strips, are used for the apparatus wiring in the same consecutive order. This is shown at "*g*" in Fig. 1. By this arrangement

any crossing of the wires inside the fitting is avoided, and each side of the mounting serves to circuits both on the line and apparatus sides.

A special type of knife-blade fuse has been designed for use with the fitting, and these are carried by means of the fuse holders referred to above. The fuses are arranged in alternate positions on the ebonite strips, so that a spacing, centre to centre, of 11/16" is obtained, whilst at the same time keeping the mounting in a compact space. The fuse consists of an asbestos covered wire, set in a slotted strip of fibre. At each end, the fuse wire is connected

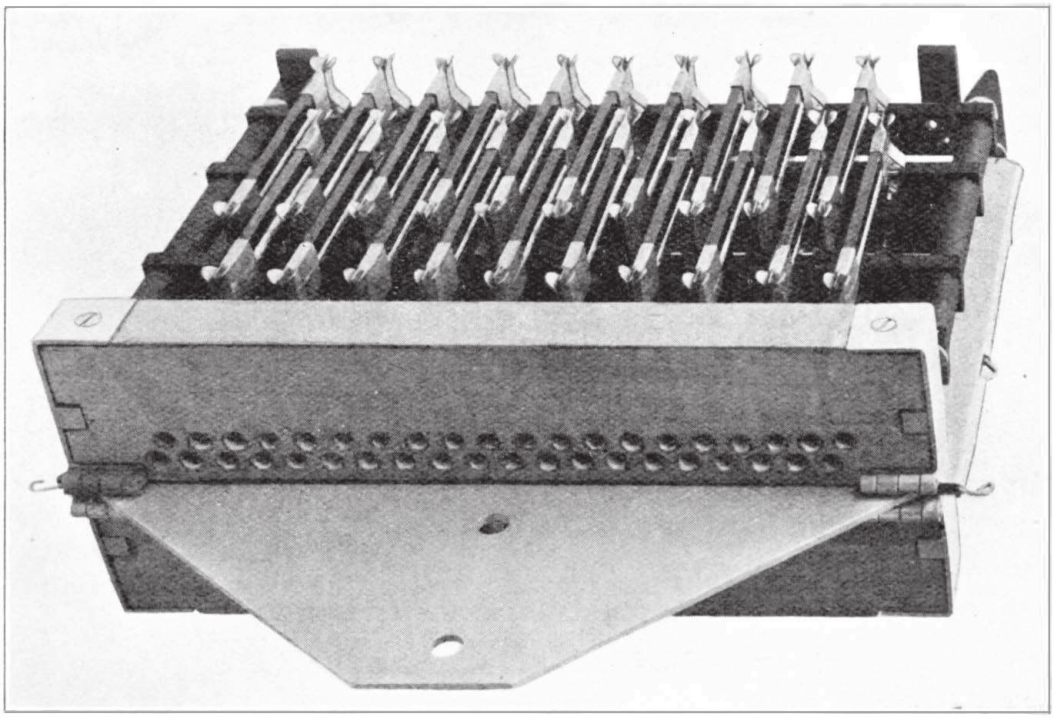


FIG. 5.—BACK VIEW SHOWING MOUNTING PLATE.

by a screw to a flat tinned copper sleeve, which is knife-shaped for insertion in the fuse holder. Details of the fuse are shown in Fig. 2.

The spread of the mounting in its open gate position is limited, to avoid any possibility of fouling with adjacent fittings and so making metallic contact through the fuse holders. A further safeguard in this respect is provided by means of four ebonite stops. This is shown at "*h*" in Fig. 1.

Fasteners are provided at the top and bottom of the mounting to maintain the closed position before fixing the dust proof cover.

Fig. **3** shows a front closed view of the mounting; Fig. **4** a side closed view; Fig. **5** a back view, with the plate for connecting to the Main Distribution Frame, whilst the mounting enclosed in its dust proof metal cover is shown in Fig. **6**.

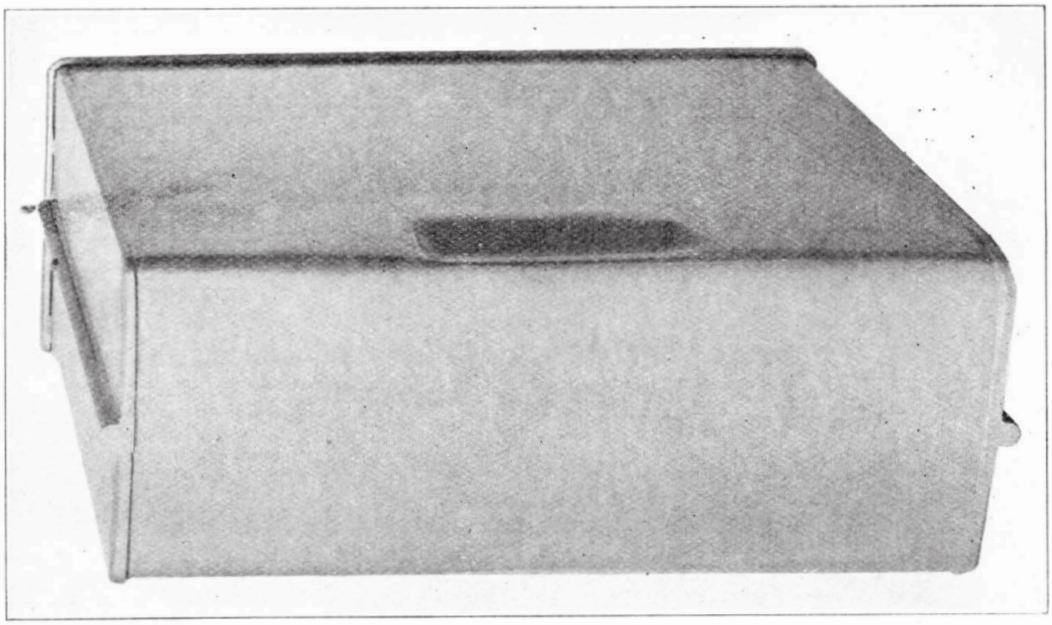


Fig. **6**.—Mounting in Dust Proof Metal Case. Shown Horizontally.

The new type of fuse mounting will be fitted in place of the Trunk Test Tablet in all future cases and will effect savings in the cost of terminating loaded and balanced cables; space will also be saved in Exchange Test Rooms.

The new mounting will also be used at Telephone Exchanges where unloaded, non-balanced Trunk cables, Junction cables and Telegraph cables are terminated.

THE PASSING OF BLACKFRIARS POWER STATION.

PROVISION was made in the Act authorising the construction of the Post Office (London) Railway that tenders should be invited for the electric power required for its operation. As the Railway load by itself is not of a very favourable nature it was decided to invite tenders for the whole of the supply required for the P.O. Headquarter buildings—formerly supplied from Blackfriars Power Station—plus the estimated requirements for the Railway, and invitations were accordingly sent to all the authorised Under-

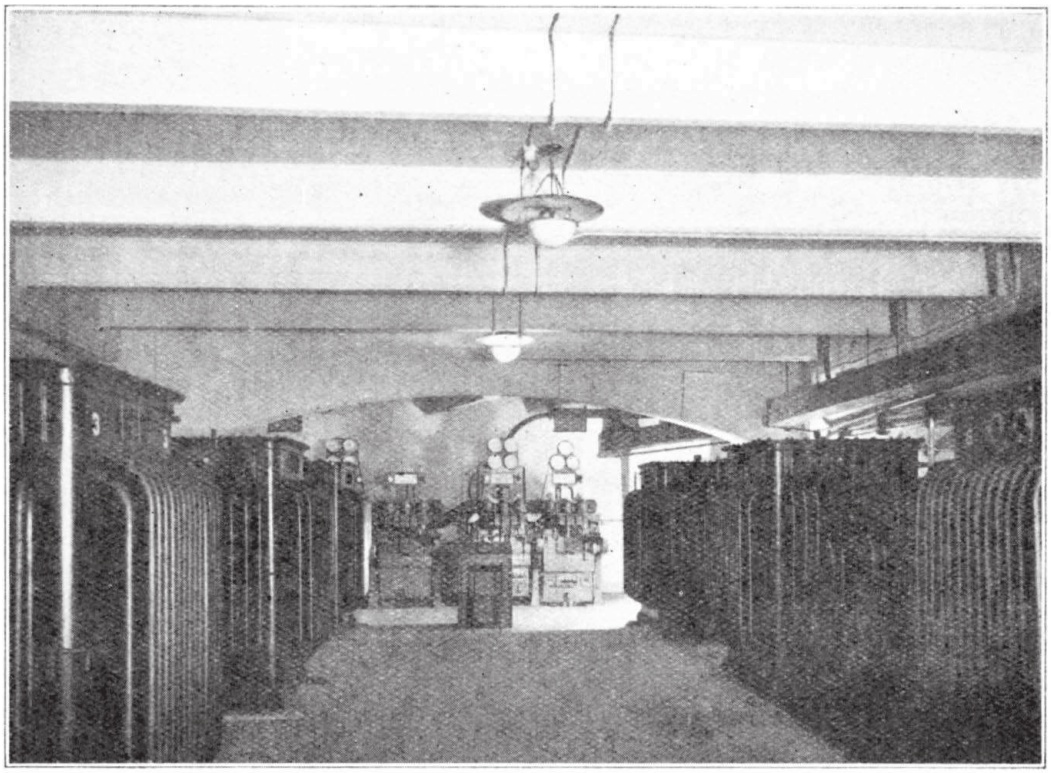


FIG. 1.—SUPPLY COMPANIES' SUB-STATION.

takers in the districts through which the Railway passes. The ultimate requirements were given as 10,600,000 units per annum with a maximum load of 3,900 kilowatts. Keen competition to secure the load ensued and eventually the joint tender of the City of London Electric Lighting Co. and the Charing Cross Electric Supply Co. was accepted and an agreement for a term of 25 years negotiated. The agreement provides for a variation in the price of power depending on the cost of coal or other fuel, and also for extra payments if a fixed maximum demand is exceeded during certain hours in the winter months; the batteries in the P.O. sub-stations will be used to reduce this as far as possible. Pay-

ment is made per kilo-volt ampere-hour, thus protecting the supply companies against the Post Office using current at a low power factor.

Under the terms of the agreement the Post Office provided the Companies with a sub-station in King Edward Building Basement, adjoining the existing Post Office sub-station. In this sub-station the Companies installed two banks of transformers with the necessary E.H.T. switchgear, each bank being capable of dealing with 3,750 kilowatts and supplied with independent mains direct from Aldersgate sub-station of the City of London Company and Ludgate sub-station of the Charing Cross Com-

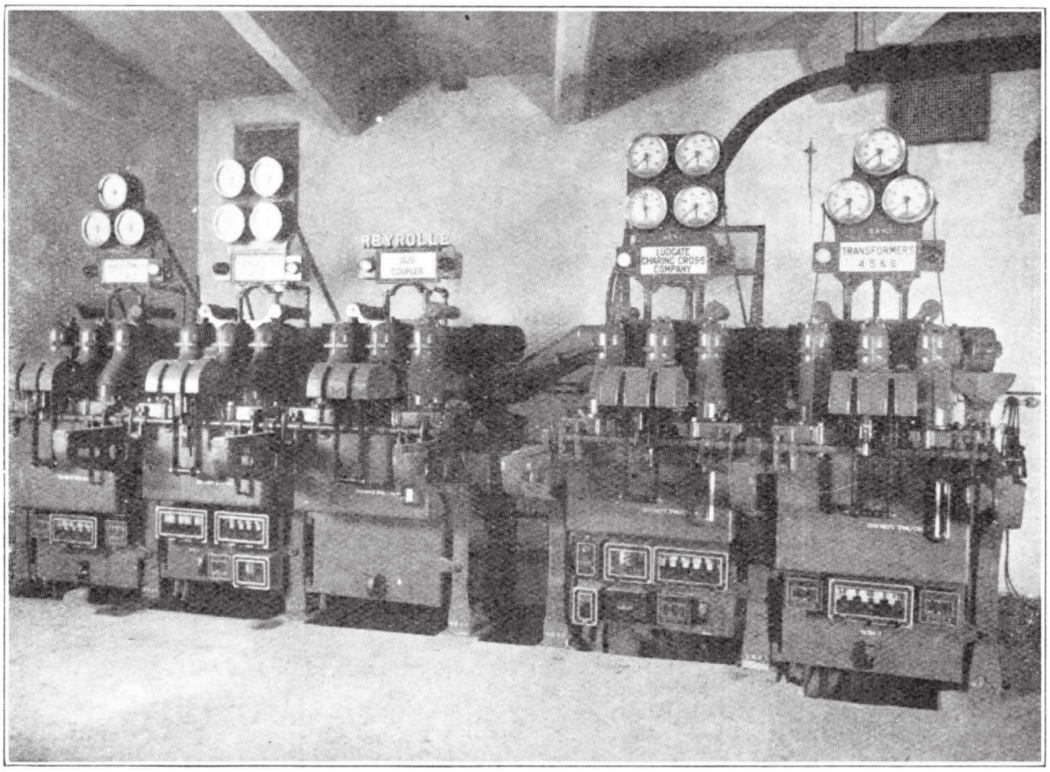


Fig. 2.—Close up View of E.H.T. Switchgear.

pany. The supply is brought in at 10,600 volts 3-phase 50 periods and trasformed down to 6,600 volts, which is the Post Office E.H.T. voltage, and is metered at this latter voltage. A general view of the Companies' sub-station is given in Fig. 1, and a close up view of the E.H.T. switchgear in Fig. 2. Direct telephone communication is provided between the Companies' sub-station and the generating stations at Bankside and Bow, respectively, and also the Post Office sub-stations.

The supply at 6,600 volts is led to the Post Office sub-station, in which additional E.H.T. switchgear has been installed to receive it; this was supplied by Messrs. Ferguson, Pailin & Co.

A view of this switchgear is given in Fig. 3, and of the metering panels in Fig. 4.

The Post Office distribution system consists of sub-stations at G.P.O. (West), Mount Pleasant, King Edward Building and G.P.O. (South); in addition there are two sub-stations on the Railway, at Western Parcel Office and Liverpool Street. G.P.O. (West) and Mount Pleasant supply direct current only and are equipped with rotary converting plant with a large battery of accumulators in each case; King Edward Building and G.P.O. (South) are equipped with static transformers and supply alternating current only. On a failure of supply occurring, the D.C.

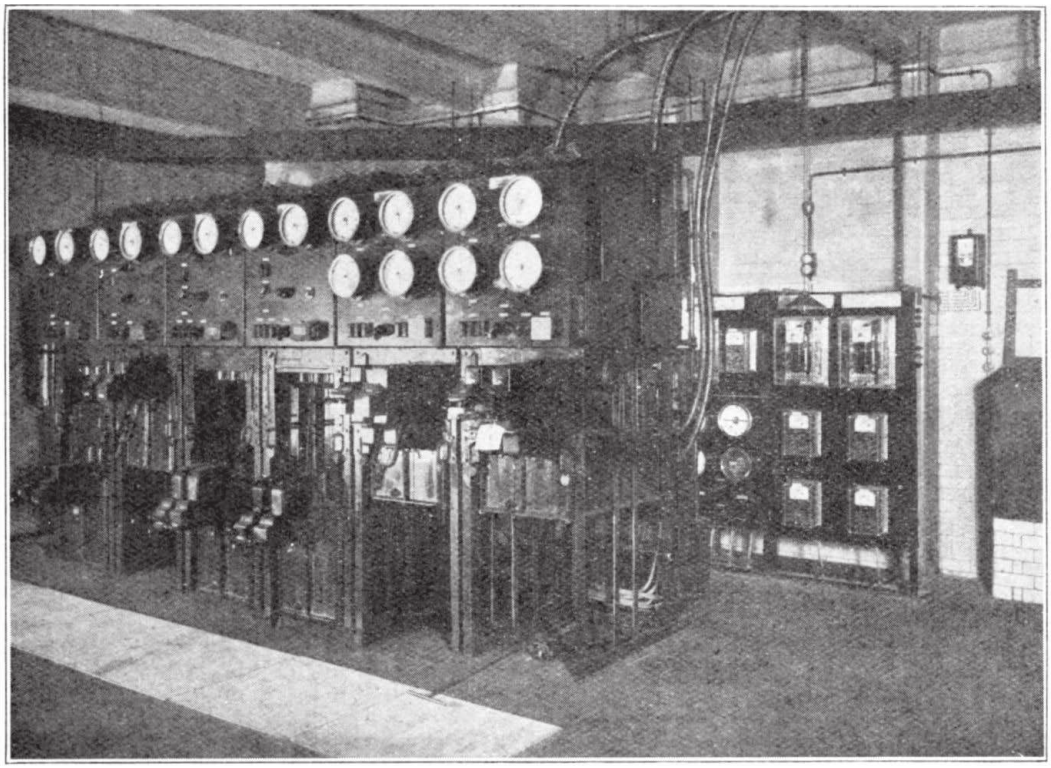


FIG. 3.—ADDITIONAL E.H.T. SWITCHGEAR IN P.O. SUB-STATION.

supply at G.P.O (West) and Mount Pleasant is maintained from the accumulators, and at the same time the rotary converting plant is reversed, supplying back A.C. to King Edward Building and G.P.O (South), as has been done in the past when Blackfriars was operating. The batteries are capable of maintaining this supply for about 1 hour at full lighting load, the main power load, such as the pneumatic plant and Railway being automatically tripped; in addition emergency steam plant to the extent of 400 kilowatts is installed at Mount Pleasant. The Companies stipulated that under no conditions must their two supplies be joined in parallel; the supply is therefore taken from

each Company during alternate months, except in the event of a failure, when the supply is changed over as may be required. The change-over is effected by taking the incoming supply to Mount Pleasant on a spare feeder; it is then synchronised on the E.H.T. side with the rotary plant, which is running reversed off the battery.

The change of supply involved considerable alterations to the existing switchgear and cable system; the first was carried out by the British Thomson-Houston Co. and the latter by Messrs. W. T. Glover & Co., additional switchgear was installed at G.P.O. (South) by Messrs. Reyrolle & Co., and an additional

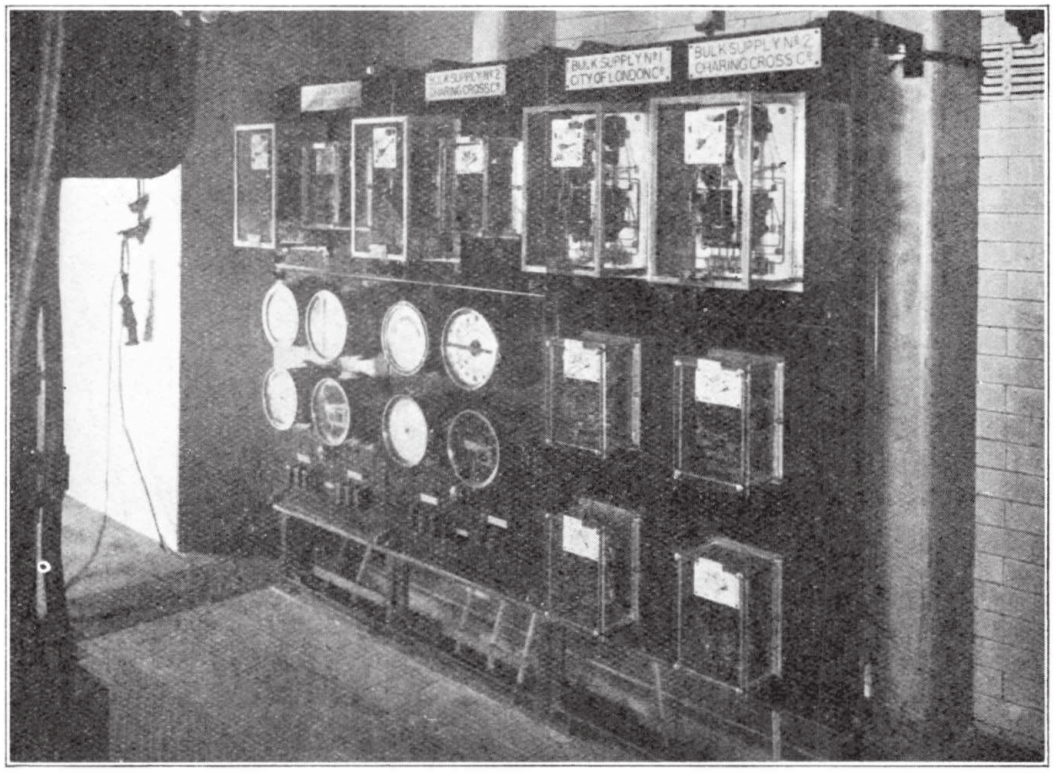


FIG. 4.—METERING PANELS.

feeder to Mount Pleasant by the British Insulated & Helsby Co., in each case to the Department's specifications.

The supply was first given by the Companies on February 9th, 1926, Blackfriars Power Station being held in reserve for a fortnight until the new arrangements were proved satisfactory; no hitch occurred in the changeover, and the whole supply has been taken from the Companies since the above date.

It is interesting to recall that Blackfriars Power Station was started up in the autumn of 1910 and has operated uninterruptedly since with only a few minor failures. At the time of the opening of the station it was larger than many public supply stations, and

during the whole of its life has compared very favourably with stations of similar size both as regards output and economy of operation. Owing to the enormous growth in modern electric supply stations, Blackfriars became comparatively a very small station and, naturally, was unable to compete in operating costs with stations of 40 or 50 times its capacity equipped with large modern generating units. The station has justified its erection, both from the point of view of economy and security of supply during its life of $15\frac{1}{2}$ years, including the war period and the troublous times that have followed it; without it there is no doubt that the Supply Companies would never have offered such favourable terms as have now been obtained.

It will be seen from the above description that, while Blackfriars Power Station has now been closed down, an extensive and very important distribution system including six substations remains to be operated by the P.O. Engineers.

E.H.W.

THE TRAINING OF OFFICERS OF THE BRITISH POST OFFICE ENGINEERING DEPARTMENT IN PRECISION TESTING OF UNDERGROUND CABLES.

By A. B. Morice, B.Sc. (Eng.), A.M.I.E.E. and
A. Morris, A.R.C.S., A.M.I.E.E.

For a number of years, courses of instruction in precision testing of underground cables have been held, from time to time, in the Research Section of the Engineer-in-Chief's Office. These courses were commenced in 1920 in order to provide special training for suitable Engineering Officers so that the efficient maintenance of the underground telephone cable system of the United Kingdom could be successfully carried out.

The reasons which led up to the decision to use air-space, paper-insulated, lead-covered, underground cables for the long-distance telephone system of the United Kingdom are detailed very fully in a paper read before the Institution of Electrical Engineers*. In Fig. 14 of that paper there is shown the proposed system of underground cables then in course of construction. At first the special maintenance testing of these cables was carried out by Research Officers, but as the scheme progressed it was recognised by the Lines and Telegraph Sections of the Engineer-in-Chief's Office that an adequate staff of trained Officers in the

* Sir William Noble: "The Long-Distance Telephone System of the United Kingdom," Journal, I.E.E., April, 1921, Vol. 59, p. 389.

Districts was necessary in order to undertake the maintenance of the extending network of cables. This need has been met, as occasion demanded, by the special courses of instruction about to be described.

Up to the present about 160 Officers, selected from all the Engineering Districts, have attended courses of training at the Research Section and consequently there exists in each District a number of Officers specially trained to deal with the testing and maintenance of underground cables.

The subjects dealt with in these courses may be broadly described under the following two headings:—

1924-5 CLASS. MR. MORICE IS THE SIXTH FIGURE FROM THE LEFT IN THE FRONT ROW, MR. MORRIS THE SEVENTH.

(A) Maintenance tests and localisation of faults.

(B) Balancing and acceptance tests.

Originally, separate classes were arranged in each of these subjects, but in the last two classes held, viz., those in November, 1924, to February, 1925, and in November, 1925, to February, 1926, both subjects were dealt with during one period of instruction. By means of a series of lectures, practical work in the laboratory, and tests of cables during and after completion, it has been the endeavour to give a complete course of instruction in the latest and most precise methods of testing modern balanced and loaded cables of high insulation resistance.

The two photographs show the members of the classes just

referred to, and a detailed description now follows of the courses of instruction given to them.

(A) *Maintenance Tests and Localisation of Faults.*

The most important maintenance tests for a paper-insulated, underground cable are, undoubtedly, insulation resistance tests. If this resistance remains at a satisfactory figure, it can then be concluded that the dielectric is dry throughout the cable length and also that most probably the lead sheath of the cable is in a perfectly sound condition.

The minimum insulation resistance specified for these cables during construction is 10,000 megohms per mile per single wire,

1925-6 CLASS.

when tested against all other wires in the cable earthed. It is very necessary to maintain this figure and it will therefore be appreciated that first-class maintenance testing is required.

It is of great importance that the regular maintenance tests should detect an insulation fault in its early or incipient stage and that suitable localisation tests should be made speedily in order to clear the trouble before it has had time to extend.

Periodical maintenance tests are made with a 500 volt constant pressure, motor-driven megger. The maximum scale reading of this instrument is 1000 megohms, so that the presence of a low insulation fault, even in its early stage, can be detected.

Methods have been developed in the Research Section and

were given in this course of instruction by which it is possible to make an accurate localisation of an insulation resistance fault in its early stage of development. The fault resistance is then of the order of several hundred megohms and, consequently, does not interfere with the traffic of the cable. By removing the fault in its incipient stage considerable economy is effected by avoiding the loss of revenue which would be caused by a complete breakdown and also by limiting the extent of the damage caused by the fault and the consequent cost of repair. In some cases the early elimination of a fault in the cable sheath may save a complete cable length from irremediable damage.

In order to illustrate the kind of insulation resistance fault which can be localised and cleared by trained Officers in the Districts an example will now be mentioned. A fault of 500 megohms existed on one wire of an underground cable 100 miles long. The weight of the conductor was 100 lbs. per mile and the fault was localised to the nearest joint between 1/10th mile cable lengths.

This maintenance course dealt with all the different kinds of faults which may be met with in practice and suitable methods of localisation were described. The limitations of the various methods as well as the precautions to be observed to ensure accurate results were fully dealt with. Instruction was also given in the order of making localisation tests so as to obtain precise results in the shortest possible time.

The preliminary work of this course was of a mathematical nature and was arranged to provide sufficient information so that the solution of general bridge networks used in electrical testing could be carried out in a methodical manner. It was necessary for those attending the course to have reached a clearly defined stage in their mathematical studies if full benefit was to be derived from the instruction given. In the case of those members of the class whose mathematical knowledge was insufficient, information was given which enabled them to gain the necessary knowledge by private study outside the class hours.

After the mathematical work had been thoroughly grasped and a number of examples worked out in detail, the electrical testing work was commenced. The following syllabus will give a general idea of the ground covered by the maintenance testing and fault localisation course :—

(1) Theory of determinants and rules for their solution.
(2) Application of determinants to the solution of simultaneous equations.
(3) Kirchoff's Laws and the solution of bridge networks by means of determinants.
(4) Measurement of Insulation Resistance — possible

methods and standard method for maintenance testing.

(5) Description of motor-driven, 500 volt megger, including precautions to be observed in its use particularly on coil-loaded cables and the uses of the guard terminal.

(6) Measurement of Conductor Resistance—loop, single-wire, and differential tests.

(7) Localisation of simple low resistance Earth Fault and of Contact Fault by means of (*a*) Varley, (*b*) Murray loop test.

(8) Description of D.C. precision testing apparatus.

(9) Localisation of Low Insulation (Incipient) Fault in long cable—general case with Varley test, lines of equal or unequal resistance, testing from one or both ends and fault in three stages of development.

(10) Actual connections for Varley test for Low Insulation (Incipient) Fault—precautions in testing, errors to be guarded against, elimination of earthed battery, double-ended test without discharging cable between tests, etc.

(11) Localisation of Low Insulation (Incipient) Fault in short cable—general case with Murray test, lines of equal or unequal resistance, testing from one or both ends and fault in three stages of development.

(12) Actual connections for Murray test for Low Insulation (Incipient) Fault—precautions in testing, errors to be guarded against, effect of resistance of testing leads, etc.

(13) Description of A.C. precision testing apparatus.

(14) Localisation of Disconnection Fault in long cable by D.C. ballistic tests.

(15) Localisation of Disconnection Fault in short cable by A.C. tests.

(16) Localisation of High Resistance (Copper) Fault in long cable by D.C. tests.

(17) Localisation of High Resistance (Copper) Fault in short cable by A.C. tests.

(18) Localisation of Complete Breakdown in cable.

(*a*) Tests from the ends on long cable.

(*b*) Tests on short cable, including A.C. search coil test.

(19) Regular maintenance tests and cable records.

(20) General directions for localisation of faults, including order of making tests, tests on the road, etc.

(21) Practical tests in the laboratory, *e.g.*, localisation of

artificial low insulation faults of 50 to 500 megohms, localisation of artificial disconnection faults, etc.

(22) Localisation of actual cable faults.

Each Engineering District has been provided with at least one set of precision testing apparatus so that the maintenance and fault localisation tests can be carried out by trained Officers. The work of these Officers, in conjunction with each other and with those responsible for the cable construction and repair work, has resulted in a high standard of maintenance of the underground telephone cable system of the United Kingdom.

(B) *Cable Balancing and Acceptance Tests.*

The work of this course was directed to instructing selected members of the Staff of each Engineering District in the field—constructional operations relating to balanced and loaded trunk cables.

In describing the scope of this portion of the work, the operations involved in the field construction of the Department's modern trunk cables will be briefly described, particular reference being given to the testing work performed at each stage, since it was in respect of this testing work that the special instruction was furnished.

The Department's trunk cables are, in the general case, manufactured, drawn into ducts and jointed into loading coil sections by Cable Contractors. Electrical balancing for the purpose of securing interference immunity and longitudinal uniformity of the line constants is effected during the jointing stage of the work, on the completion of which the loading coil sections are submitted by the Contractor for acceptance by the Department.

The balancing methods adopted by British Contractors follow generally the standard practices of the Department.

Descriptions and theoretical explanations of these practices constitute the major and most important portion of the work of this course. Capacity and conductor resistance balancing, for the elimination of cross-talk, and mutual capacity balancing for the promotion of longitudinal uniformity of cable circuits were dealt with. The instruction furnished in this branch was complete and was framed so as to permit, when necessary, of cables being drawn in, jointed and balanced by the Department. Such work has in consequence been successfully performed on more than one subsequent occasion by the trained Staff of the Districts. Furthermore, in those cases where damage to a cable has resulted in replacing lengths of cable being required, the loading coil sections involved have been rebalanced by such local staff. The operations involved in these cases are always more difficult than in the case

of new constructional work and are frequently rendered rather involved and complicated by the necessity for keeping circuits working through the cable during the progress of the work. The advantage of having staff available in such cases who possess familiar knowledge of the original construction, and of what will be involved in the work of restoration, has been frequently demonstrated. Such cases of breakdown have been expeditiously handled from the outset, the temporary restoration of service being carried out in such a manner as to facilitate to the greatest possible extent the subsequent permanent repair work.

Up to quite recently the acceptance of loading coil sections from Contractors has been carried out wholly by special testing staff under the control of the Research Section of the Engineer-in-Chief's Office. Trained staff, equipped with the necessary apparatus, is now available in the Districts for the execution of this branch of the work. In addition to insulation and conductor (loop) resistance tests, capacity unbalance, resistance unbalance, cross-talk and mutual capacity measurements are made. Full instruction in these tests was furnished in class, whilst the practical work of the course provided for each officer being attached for a period to a headquarters group actually engaged upon such testing operations.

On acceptance of the loading coil sections the loading coils are inserted, generally by the Department's own workmen, under the supervision of the Superintending Engineers. In the case of side circuit loading only, this work proceeds systematically to completion without the necessity for further special testing other than regular insulation, conductivity and tapping-through tests. On completion, end-to-end or final tests are made prior to bringing the cable into service. These final tests involve special measurements for inductance, cross-talk and noise, and transmission efficiency. The inductance tests are intended to check the freedom of the coils from deterioration due to the inadvertent passage of large currents, reversals of coil windings, the preservation of the Multiple Twin formation of the cable through the coil case—*i.e.*, freedom from split pairs and split cores—and generally the correctness of the loading operations. The transmission or speaking efficiency tests, by comparison of a number of cable loops with an artificial cable, enable the average attenuation and the terminal loss values to be computed. Instruction in such tests does not normally form part of the cable balancing course, but in some cases where time and other circumstances were favourable, lectures were given and opportunities afforded for practical work on completed cables.

In the case of long-distance side- and phantom-loaded cables it is necessary to secure a greater degree of interference immunity

than in the case of short, side-loaded cables. This is attained by crossing methods at joints between groups of loading coil sections and coils, the actual mode of connection being determined by the results of cross-talk switching tests. In this case also, detailed class instruction could not always be arranged. The best that could be done in this connection was to provide for brief lectures and a measure of actual work on the road for those officers whose duties in their own districts included the control of staff engaged upon the making of such joints or otherwise handling such cables, *e.g.*, during the carrying out of the above mentioned group tests or during maintenance operations.

The following brief syllabus outlines the work of the Cable Balancing and Acceptance course :—

(1) *Mathematics.* A brief review of elementary mathematical processes with special reference to vectors.

(2) *Elementary Alternating Current Theory.* Simple sine-wave alternating current representation. Impedance and Admittance regarded as vectors. Resistance, Reactance, Conductance and Susceptance. Equivalent direct impedance and admittance networks. Application to direct capacity networks. Solution of impedance and admittance bridges of N members by reduction to 4 member networks and use of Wheatstone principle.

(3) *Cable Balancing.* Capacity balancing for interference freedom, along the lines of T.I. XIX. Conductor resistance balancing. Balancing for limitation of circuit and of length deviations of mutual capacity. Rebalancing methods suitable to different conditions of cable failure.

(4) *Acceptance of loading coil sections of cable.* Descriptions of apparatus and methods of measuring insulation resistance, conductor resistance (loop and unbalance), capacity unbalance, cross-talk and mutual capacity with special descriptions of Post Office Trunk Cable, Conductor Resistance (loop and unbalance), Capacity Unbalance and Cross-Talk Testing Sets and their associated equipment. Mutual Capacity bridge.

In addition to the foregoing some general information relating to these courses will be given.

The members of the courses so far held have been selected by Superintending Engineers. In May, 1923, when a number of officers were required to staff the Headquarters testing groups, suitable men were chosen on the result of a written examination. Of 300 candidates, competing from various parts of the country,

40 were so chosen and subsequently given a suitable course in the work which they were required to perform. They were then allocated as assistants to testing groups and many have since qualified themselves to take charge of a testing unit.

The courses have been given to staff of various ranks from that of Assistant Engineer to Skilled Workman, and they have been adapted as far as possible, from time to time, to meet the special needs of the officers concerned. The methods of explanation and the amount of preliminary work has also been varied to suit the scientific and technical attainments of the members of the several courses which have been given.

In those cases where by reason of the rank of the officers attending a course their normal duties would be largely of a supervisory character, much more general ground relating to the trunk system has been covered and particular attention has been given to the organisation aspect of the work. In other cases the need has been for considerable detail in the testing, recording, selecting and scheduling aspects of cable work.

The writing of lecture and laboratory notes has been provided for. The books have been examined and corrected from time to time and on completion of the courses. Close touch between the lecturers and their assistants and the members of the class has been maintained with very beneficial results.

Present day policy shows some tendency to the placing of cabling contracts involving manufacture, jointing, loading and terminating to completion. By this means it is hoped to relieve the Department of much of the testing work at present carried out. The staff will still, however, require to keep thoroughly up-to-date in this constantly developing aspect of communication work, since they will be closely concerned not only with the inspection of such work in all its constructional stages, but also with the subsequent maintenance and working of the system.

Although no mention has been made of the testing of gutta-percha and balata insulated submarine cables, yet some of the officers who have attended the classes have had to deal with the maintenance testing of such cables in their normal duty. In such cases, some time has been spent in dealing with this important branch of cable work.

In conclusion, it will be noticed that, up to the present time, the classes have been held intermittently and only on such occasions as the need for the immediate services of trained staff arose. It is the opinion of the authors that the future adequate maintenance of the cable system of this country will necessitate the training of suitable officers as a regular feature of the Department's policy.

It will also be observed that the scope of the courses so far

given has not included the special line requirements of repeatered cables. In the acceptance of such cables, impedance-frequency tests of the circuits are necessary to prove their satisfactory length-uniformity. Special cross-talk tests to cover the cable and the repeater station line apparatus, as well as overall efficiency tests to cover the behaviour of the line under the energised conditions of the repeaters, are also essential. The maintenance of such circuits will include a similar series of tests, the checking of line balancing networks and of repeater gains. The necessity for trained staff to deal with this aspect of the work is obvious and it is suggested that the need could very well be met by a course along the lines of the Cable Maintenance and Balancing courses described in this article.

ACCIDENTS ON DUTY.*

By R. A. Jones.

One of the most striking phenomena of the industrial history of the last hundred years is the amelioration of the conditions of employment of the worker. The exploitation of child labour, excessively long working hours, and insanitary, unsuitable and inconvenient work places are but a few of the evils which have been removed or remedied by legislation, and in such enactments as the Factory and Workshop Acts regulations have been made for the protection of workers from the dangers of their work, whether accident or occupational disease. In addition to this beneficent action on the part of the State many large employers of labour have supplemented statutory provisions by the introduction of welfare, safety first and other movements for the preservation of the health and lives of their employés during working hours. And further, it is now recognised that mechanical means of promoting industrial efficiency are insufficient unless the human factor in all its variations is taken into account—hence in the scientific management of industry, which has for its object the increase of output, questions of fatigue and unrest have become the study of experts.

In these movements for the protection of the worker physical injury or disability arising out of or in the course of his employment is regarded as a menace to his general well-being, and, as any reduction of his general well-being lowers his standard of effectiveness, industrial accidents must in their results be counted

* A paper read before the North Western Centre, at Preston, on the 30th November, 1925; and before the Northern Ireland Centre on the 9th March, 1926.

as a form of inefficiency inasmuch as they cause labour losses and therefore entail unproductive costs.

To the business man the rate of profit is the measure of efficiency. In the Post Office Engineering Department efficiency is not measured by profit qua profit, for as Mr. John Lee says in his "Economics of Telegraphs and Telephones," "It is worthy of notice, as of national interest, that it is perfectly clear from the preamble of the Telegraph Act of 1868 that there was no intention whatever of making a profit out of the telegraph service, but only an intention of making the service more rapid and more widely extended," our measure of efficiency is the due provision of satisfactory engineering services. Nevertheless, it is required of public servants entrusted with public funds strictly to administer and control expenditure upon the public services which it is their function to supply. In the exercise of this administration and control of expenditure we must have regard, *inter alia*, to the elimination of all unproductive costs, among which, as we have seen, are those entailed by labour losses through accidents.

The elimination of the unproductive costs of accidents can only be effected by the prevention of accidents, and if it were asked what number of accidents may be regarded as the irreducible minimum the answer would be "none." This no doubt is idealistic, but it is not impossible, and it must be the aim if any considerable reduction in the number of accidents is to be secured.

If we would avoid accidents we shall do so most surely by a study of their causation and by the adoption of those means of prevention which are indicated by such a study.

The inevitability of accidents seems to be too readily taken for granted—hence perhaps the reluctance to ascribe contributory negligence, which is admitted in only two per cent. of the cases reported in the North Western District. This may be the outcome of failure to appreciate the precise nature of an accident and a too easy assumption that any and every occurrence by which the person is injured is veritably unavoidable and could not be prevented. An accident according to the New English Dictionary is, "Anything that happens without foresight or expectation; an unusual event which proceeds from some unknown cause or is an unusual effect of a known cause." According to Webster's Dictionary an accident is literally, "A befalling; an event that takes place without one's foresight or expectation; an undesigned, sudden and unexpected event." In the legal sense an accident is, "An event happening without the concurrence of the will of the person by whose agency it was caused; an accident differs from a mistake in that a mistake always supposes the operation of the will of the agent in producing the event, although that will may be caused by erroneous impressions on the mind." Specifically,

in equity practice, an accident " is an event which is not the result of personal negligence or misconduct." On the inevitability of of accidents Dr. P. Sargant Florence, an authority on the subject, of the Department of Economics in Cambridge University, in his " Economics of Fatigue and Unrest," writes, " Accidents are often enough accepted as a dispensation of Providence. This may be true of earthquakes, volcanic eruptions, storms and tempests, but in the humanly created conditions of industry accidents must take their place beside turnover, lost time and deficient and defective output as a symptom of human inefficiency," and again, " The word accident, by its very derivation, denotes something which should not happen at all . . . and all industrial accidents arising out of and in the course of employment might be considered as avoidable by the employer." And this is the testimony of the British Health of Munition Workers' Committee in a published memorandum of the results of an inquiry made by them: " Accidents depend in the main on carelessness and lack of attention of the workers, and so the more one can eliminate this lack of attention and increase the concentration of the worker upon his work the more will accidents be reduced." Those who know most of the facts and are therefore best qualified to judge agree that the number of industrial accidents might be greatly reduced. The Chief Inspector of Factories and Workshops says 75% of the accidents that occur could, with reasonable precaution, be avoided. In the face of this well-informed evidence an accident in the course of employment cannot be regarded as inevitable if it might have been prevented by the exercise of foresight and precaution, the application of proper methods, and the skilful use of the most suitable tools and appliances. Failure in any of these respects indicates personal negligence or misconduct, or, as Webster expresses it, the concurrence of the will of the person by whose agency the accident is caused, and these considerations should engage the attention of those whose business it is to decide the question of contributory negligence. It may be that contributory negligence is seldom admitted because of sympathy with the victim and a desire to give him the benefit of the doubt; if this be so, is not the kindness misplaced and would not it be more beneficial to explore the cause of the mishap so as to establish definitely whether it was really unavoidable, and, if not unavoidable, to apply those remedial measures or to take such disciplinary action as would, so far as is humanly possible, have the effect of preventing a similar occurrence? It is somewhat remarkable that while bad and imperfect workmanship, such as faulty plumbing and dry joints, is frequently punished, the unworkmanlike behaviour by which accidents are often caused generally goes unchallenged. As Dr. Sargant Florence says:

"Official investigations often confine their interpretation of cause to the type of machine or object inflicting the injury without inquiry into the action of the object and of the human victim immediately preceding. Variations in accidents as a measure of the injured worker's bodily and mental state and the influence upon him of industrial conditions are being gradually recognised, *e.g.*, an accident due to the glancing or slipping of a tool represents a case in which the injured man's state of mind or body may have considerable influence, but an accident due say to the breaking of a tool is a case where the human factor in the person of the user of the tool could have little or nothing to do with the circumstances." Mr. Henry Ford, of motor car fame, in "My Life and Work," writes of the practice of his own establishment: "Every accident, no matter how trivial, is traced back by a skilled man employed solely for that purpose, and a study is made . . . to make that same accident in the future impossible."

"If a man has worked too hard or through too long hours he gets into a mental state that invites accidents. Part of the work of preventing accidents is to avoid this mental state, part is to prevent carelessness, and part is to make machinery absolutely fool-proof."

According to Mr. Ford, the principal cause of accidents as they are grouped by the experts are:—

(1) Defective structures.
(2) Defective machines.
(3) Insufficient room.
(4) Absence of safeguards.
(5) Unclean conditions.
(6) Bad light.
(7) Bad air.
(8) Unsuitable clothing.
(9) Carelessness.
(10) Ignorance.
(11) Mental condition.
(12) Lack of co-operation.

And he further remarks: "The question of defective structures, defective machinery, insufficient room, unclean conditions, bad light, bad air, the wrong mental condition and the lack of co-operation are easily disposed of. None of the men works too hard. The wages settle nine-tenths of the mental problems, and construction gets rid of the others. We have then to guard against unsuitable clothing, carelessness and ignorance, and to make everything we have fool-proof. . . . Industry needs not exact a human toll."

It has earlier been suggested that any effort to reduce the frequency of accidents is more likely to be successful if it be

informed by a study of accident causation. To this end and in the hope that the results will prove to be useful the accident records of the North Western District have been explored and a number of analyses made, of which particulars will now be given.

The number of accidents on duty during a recent year was 186—rather more than one every two working days. The average number of workmen employed was 1,200 and the percentage of accidents was therefore 15.5. The number of days lost was 1,950, or the equivalent of the continuous absence of 6.3 men. The average absence for all accidents was 10½ days, but as 96 of the accidents involved no absence the average absence for the 90 which did involve absence was 21.6 days. The average absence per employé was 1.6 days.

It is difficult to make any useful comparison between the frequency and severity of accidents sustained by the Department's workmen and of accidents sustained by workmen generally as, the Department's work being peculiar to itself, the available statistics of casualties in other industries are not strictly applicable. The case of workers in the dockyards and other establishments of the Admiralty provides perhaps the nearest parallel. There the frequency rate was 30.5, as against this Department's 31.7, and the severity rate .38 as against .68. (The frequency rate is the number of lost-time accidents per million hours worked and the severity rate the number of days lost per thousand hours worked). It will be observed that while the frequency rates are remarkably close, this Department's severity rate, indicating the time lost, is nearly double that of the Admiralty worker.

The frequency of all temporarily disabling accidents in industry generally is given as about 110 per thousand employed. Of these 110 accidents, about 45 accidents a year will probably disable from a day to a week, 48 from a week to a month, and 17 from a month to six months. The general frequency rate of 110 per thousand comes remarkably close to this Department's frequency rate of 109. There is, however, some difference in duration, the Department's figures showing more day to a week absences and less week to a month absences than is the general experience.

The distribution of accidents during the period under review throughout the several Sections of the District was Mid. Lancs. (Internal) Section, 9.1% of the number of workmen employed; Lancaster Section, 16.2%, and Preston and Rochdale Sections, respectively, 18%. The risk of accident on external work is therefore shown to be approximately double the risk on internal work and the dangers of external work to be greater in congested urban areas than in rural districts.

An attempt was made to ascertain whether, and, if so, to what extent, the incidence of accidents is affected from month to month

by seasonal differences of temperature or visibility, but, as the following particulars show, no definite conclusion was reached. In November, December, January there were 52 accidents, and in June, July, August 41, an increase of 11 during the winter months, but as against this the number was as high as 19 in May, a good weather month, and as low as 10 in February, a bad weather month. The highest peaks were 24 in March and 19 in May, October and January, respectively, the lowest, 7 in April. This is the general experience, for according to the Annual Report of the Chief Inspector of Factories for 1924 industrial accidents are always heaviest in the months of March and October.

A test was made of the incidence of accidents on the several days of the week, to ascertain whether the freshness of Monday or increasing fatigue as the week advances has any marked effect on the risk. In 200 cases examined, 47 accidents happened on Tuesdays, 42 on Fridays, 41 on Mondays, 27 on Thursdays, 25 on Wednesdays and 18 on Saturdays. The general experience is that most accidents happen on Mondays and Fridays; with us Tuesdays and Fridays are the worst days.

The number of accidents during each hour of the day was investigated to ascertain to what extent liability to accident may be affected by fatigue or hunger. Of 200 cases it is significant that the highest figures were 39 accidents in the fourth hour of the day and 29 in the eighth hour. From this it would appear that fatigue and hunger do increase the risk of accident, and this is confirmed by the fact that fewest accidents happened during the first and sixth working hours, the figures being 11 and 10, respectively.

The ratio of age to risk of accident was examined and it was found that youth is more liable to accident than age, which, on the assumption that youth is generally less cautious and certainly less experienced than age, tends to confirm the suggestion that accidents are largely due to negligence or ignorance. Workmen under 20 years of age, although only 5% of the staff, had 4.5% of the accidents; from 20 to 30 years, 34% of the staff, had 41% of the accidents; 30 to 40 years, 35% of the staff, had 29.5% of the accidents; 40 to 50 years, 19% of the staff, had 17% of the accidents; 50 to 60 years, 10% of the staff, had 8% of the accidents; and over 60 years of age, 7% of the staff, had no accidents. It will be noticed that the highest ratios are those in the groups under 20 years and from 20 to 30 years of age.

It is not surprising to find that the hands suffer the majority of the accidental injuries—85 of 186, or 45%. The head follows, a long way behind, with 19 injuries, and the legs come next with 18. The eyes, with 17 injuries, fare better than might be expected of a member so vulnerable. Of the remaining members the back

suffers in 16 cases, the feet in 12, the arms in 10, the knees in 7 and the chest in only 2.

In the year under review there were 9 accidents in connexion with motor vehicles and during a subsequent period of 9 months the number was only 5. This is a gratifying reduction in this type of accident, having regard to the increasing congestion and dangers of the roads, and reflects credit on the drivers.

Some people, by their awkardness, clumsiness or foolhardiness, or owing to a physical or mental kink—people who do not possess the accident sense—seem to be specially susceptible to accidents. These are they who incur multiple accidents. An examination of the records was made for cases of successive accidents to the same person, to ascertain whether there were any of these susceptibles among the Department's employés. In a period of 18 months, 18 men each sustained two and one man three accidents, and an instance of three accidents within 10 months to the same man came to notice a few days ago. This last case is worthy of recapitulation :—

On the 15th November, 1925, C. scratched the third finger of his left hand with a piece of bronze wire. The wound was not medically treated until the following day. This was the third accident to C. in 10 months. In January he scratched his hand with a wire end and was absent 44½ days, suffering from a septic wound; on that occasion medical attention was not obtained for three days. There was a second accident in April, when C. knocked his hand against a bolt and cut a finger. The most recent injury developed into a septic arm, no doubt rendered septic by the delay in receiving treatment, and the medical officer recommended that C. should in future wear gloves. Whether he will be able to work in gloves or whether, having now protected his hands, some other part of his frame will suffer only time can tell.

On this point the Industrial Fatigue Research Board, in a report on the Incidence of Industrial Accidents, observes that the explanation of this special suspectibility is to be found in the personality of the individual, and that a worker who has had three trivial accidents is a more dangerous person than one who has had a single bad wound.

Safety first methods and devices for the prevention of accidents are now largely employed in all well-conducted industrial establishments, and there is abundant evidence of their success in the reduced rates of frequency and severity. The P.O. Engineering Department is not behind general practice in its appreciation of the importance of the subject. A body of literature and instruction on the matter is to be found in the Department's Regulations, in the brochure "Precautions against Accidents," in Rules for

Workmen, and indirectly, as conducing to workmanlike methods and the skilful use of tools and appliances, in the Department's Technical Instructions and the Pamphlets for Workmen. If the slogan :—

> "*Know* these instructions and apply them even where there is no risk. Report every accident without exception."

prominently printed in red on the covers of "Precautions against Accidents," were generally observed the effect could not fail to be a great reduction in the number of accidents. And it has been written :—

"Industrial accidents are usually neither wholly humanly circumstanced nor yet wholly mechanically, but arise most commonly from the fact that potentially errant human nature is employed on potentially dangerous operations. Anticipation of the likely errors and dangers has substantially reduced the accident rate in several industries and plants, and the adoption of this safety policy indicates the possibility and the economy of minimizing accident."

A few typical accident cases may be of interest, and may serve to point a moral :—

(*a*) A workman removed the nut from an arm bolt and came down the pole for his dinner. Climbing the pole after dinner he grasped the arm for support, forgetting that he had removed the nut ; the arm came away and the man fell to the ground. In this case the man appears to have thought more of his dinner than of his safety and the work he had in hand. His neglect to replace the nut on the arm bolt or to remove the arm before coming down resulted in serious injury to himself (and might have caused injury to others) and loss to the Department. He was incapacitated for seven weeks The Engineer-in-Chief, while agreeing that the failure to make all secure before leaving the work was blameworthy, allowed compensation pay on the ground that it was extremely doubtful whether the man could be held to have been guilty of serious and wilful misconduct within the meaning of the Workmen's Compensation Act, 1923.

(*b*) In this case the workman was assisting to prepare a 40′ pole for erection. The pole jumped the bogey on which it was resting and threw him to the ground, causing a very severe comminuted fracture of the right leg. The pole was lying on the pole cart and as the ground was soft the cart wheels were placed on planks. The pole had been armed while on the cart and was being turned over so that steps could be fixed on the other side when one of the wheels slipped into the soft clay, causing the cart to sink suddenly on one side and the 8-way arms striking the ground levered the pole over the pole cart pins. There is no

regulation against using a pole cart to support a pole while it is being fitted, but as the ground was soft the usual trestle support composed of two stout arms crossed would have been a better arrangement, and if it had been used the accident would not have happened. *As so often occurs in accident cases the Foreman was not on the spot.* The victim of this accident was absent for 4½ months and though the functional condition of his leg has been restored there is a permanent defect in the alignment of the limb.

(*c*) A jointer and mate were about to open a joint which was very dirty. Just before they left the job for dinner at noon the joint was washed with petrol. On returning to work and before the manhole was entered an acetylene lamp used for lighting was lowered into the manhole, when an explosion took place. The two men were caught in the flames, the jointer being severely burnt on the face and hands and the mate burnt on the face, and both were incapacitated for seven weeks. The manhole was believed to be free from coal or sewer gas. The roof of the manhole was said to provide a pocket for the fumes and apparently the fire was caused by vapour from the petrol applied to the cable for the purpose of cleaning it becoming ignited by the acetylene lamp. The jointer was ill-advised to use a naked light in such a situation.

(*d*) E.H. was engaged in July, 1924, as a Labourer and on 4th March, 1925, while twisting a pole he slipped and sprained his right knee, which it was only then discovered had previously been weak and limited in movement. He was absent for two months and received compensation pay. This case illustrates the importance of ascertaining before men are engaged whether they are free from physical defect or infirmity.

(*e*) A workman got a splinter of wood in one of his fingers. Surgical aid was not sought till the following day when the finger had swollen and become septic, necessitating 2½ weeks' absence. The man, who is an Ambulance man holding several certificates, washed and attended to the wound after removing the splinter and considered that this was sufficient. The point of this case is that first aid is not intended to preclude the attention of a surgeon. The first rule of ambulance work is "Send for a doctor."

(*f*) A remarkable case is that of E.R. On the 6th May, 1921, this man, 34 years of age, was transferring wires from a ladder to a pole when the ladder broke and caught him on the nose. The injury was described by the Medical Officer as abrasion of the skin of the nose and forehead, and classified as "Slight." The ladder was a borrowed one and was set in an upright position with only two stays, and the Sectional Engineer regarded the foreman as to blame for not arranging for the ladder to be sufficiently stayed before the man ascended it. There was no absence. The man

continued to work after the accident and for more than three years afterwards. In December, 1924, he was away for 3 days suffering from syncope-Gastric and from February to August of the following year, 1925, he had successive absences of 19, 11 and 91 days, in all 121 days, suffering from syncope-Gastric, Debility and Epilepsy. His superannuation was then authorized on a retiring medical certificate describing his ailment as Epilepsy associated with marked gastro-intestinal toxæmia. On the 25th September E.R. died in hospital. The doctor who made a post-mortem examination deposed at the inquest that there was no external sign of injury to the skull, but on the inner layer of the skull cap there was a small excavation the size of the end of a lead pencil $\frac{1}{8}''$ deep. On top of the forehead a little to the right of the eye there was a small perforation of the brain about the size of the excavation, and the brain, otherwise healthy, was protruding slightly into the hole. This condition of the skull and brain seemed to be the result of an old injury by violence and not disease; there must have been a fracture four years ago. The cause of death was heart failure following the epileptic state, of which the fracture was possibly the origin. The case was referred to the Chief Medical Officer, who in view of the post-mortem examination considered that it could not be successfully maintained that the accident in 1921 was not the cause of the brain condition responsible for death, and liability under the Workmen's Compensation Act was admitted. This case is cited as a striking illustration of the serious consequences which may follow neglect to use suitable tools and to employ proper methods.

The Department's work cannot be classed as a hazardous occupation. During the last seven years only three fatal accidents have happened in the North Western District, and as will have been gathered from the foregoing particulars the risk of injury necessitating absence is as 3 is to 40. Yet it should not be forgotten that every accidental injury is a potential fatality and that as Dr. Sargant Florence puts it: "Apart from the general condition of the worker . . . . . minor accidents such as cuts or scratches do not entail lost time but are yet unquestionably responsible for lowered working capacity."

The appeal of this paper has been largely utilitarian—the need in the interests of efficiency of reducing the number of accidents on duty, but may it not be urged that the prevention of such accidents has an even greater claim on our attention on the higher ground of humanity? The money cost of an accident on duty is £7 or £8, but what it may cost its victim in physical and mental suffering and worry is incalculable.

NOTES AND COMMENTS.

THE student of telephony is rather apt to devote too much attention to the purely apparatus and exchange development side of the subject, and to ignore the connecting links and take for granted that the line plant looks after itself. It is true that the intricacies of exchange equipment—especially when one gets down to the principles of machine switching and their application to multi-office areas—are extraordinarily fascinating. The problems have been attacked and are being solved by most ingenious methods; has not someone said that automatic telephony is the high-water mark of human inventive genius? But that is not the whole story of telephone development. The modern long-distance trunk line, balanced and loaded, fitted with repeaters, echo suppressors and accurate line balances, is a product of high engineering skill and is worthy of the closest attention, not only of the student but of those whose duties may not have brought them into intimate contact with external work but yet are zealous enough in their profession to try to master all its phases. It is not possible, we admit, for any one communication engineer to assimilate all the details of all the branches to-day; the time has gone for one man to carry in his head a list of all the screws, tags, terminals and parts of every item of apparatus used by the Departments, as we believe an officer now very high in rank was once capable of doing without apparent effort. To attempt such a thing to-day would be foolish; a glance through the Stores Rate Book will disillusion anyone desirous of attempting it. Nevertheless, the field is not so wide as to debar any engineering officer

from acquiring a sufficient knowledge of essentials so that when the time and opportunity come the details can be readily absorbed.

It is for these reasons we welcome the valuable articles on the London—Glasgow Trunk and its repeater stations, by Mr. A. B. Hart, and the description of the precision testing and cable balancing courses by Messrs. Morice and Morris. The cable testing courses form a fitting conclusion to the scheme of education for its staff now carried out by the Department.

A REFERENCE TELEPHONE TRANSMISSION SYSTEM.

The telephone administrations of the world have been concerned for some time on the subject of the adoption of a reference transmission standard, one which would be stable in operation and by which the telephone of commerce could be checked for volume and for articulation and also to bring results obtained by different administrations strictly into line with each other.

Interesting demonstrations were given at the P.O. Research Station at Dollis Hill in the last week in May of apparatus developed by the American Bell System, Siemens and Halske of Berlin, and the British Post Office for use in connection with a standard Reference System. The German and British exhibits, although giving excellent results, had not been developed to the extent of the American system and it was decided, after prolonged discussion, that it would be advisable to adopt *in toto* the American system for the time being. The main points were that here was a completed system which fulfilled the requirements laid down and one on which a great deal of experience had been obtained regarding the stability of the component parts.

It was recommended that the C.C.I. should obtain a complete set of apparatus which would be known as the European Master Transmission Reference System. Administrations could maintain other Reference Systems, which, if approved by the C.C.I. as conforming to certain limits laid down, would be designated Primary Reference Systems. The necessity of a concrete Master System follows from the impossibility, at the present, of obtaining apparatus within sufficiently close limits of difference to ensure that two systems built to the same acoustic-electric-acoustic specification but using different types of apparatus would give performances identical with one another.

Secondary and working standards not involving the elaboration of the Primary Systems could be used and calibrated from them.

Briefly, the Master System comprises six parts:—A transmitter and associated amplifier, a non-reactive line of 600/0 ohms

impedance, a receiver with associated amplifier, two electrical networks (one to produce such frequency-characteristic distortion in the transmitter as to give the reference transmitter the same frequency-characteristic as that of the commercial type working standard, and another to do the same for the receiver), and, lastly, the calibration apparatus.

The transmitter used is the now well-known type of condenser transmitter, with a heavily air-damped stretched diaphragm. It is made up in a size comparable with the No. 1 C.B. transmitter and mounted upon a standard type pedestal. The line calls for no comment. The receiver is of the permanent magnet Bell type, but having the diaphragm mechanically damped by a series of thin paper discs placed below the diaphragm. The diaphragm is clamped between faced metal surfaces to ensure uniformity and permanence.

It is claimed that the transmitter and receiver maintain their calibration with great accuracy, but in order to obtain this calibration in absolute units a calibration system is incorporated. This is in reality the essence of the whole system. Calibration of the transmitter is carried out by enclosing the front of the diaphragm with a small chamber in which is held a thermophone consisting of two strips of gold leaf. If a direct polarising current be passed through this and an alternating current be superposed the heating and cooling of the strips heats the air gas in immediate contact. If the chamber in which the strip is located be small in comparison with the wave-length of sound corresponding to the frequency of the alternating current the pressure in the chamber varies in accordance with this current. Since the length of a sound wave in hydrogen is four times its value in air the calibration is carried out in hydrogen. It is claimed that it is possible to calculate the pressure in the chamber when its constants and those of the thermophone are known. The voltage output of the transmitter can thus be obtained in terms of dynes per square cm. on the diaphragm.

The receiver is calibrated by means of the previously calibrated transmitter. The thermophone is removed and the receiver, by means of a metal coupling device, placed airtight in front of the transmitter diaphragm. On passing a known current through the receiver the output in dynes per square cm. is obtained, knowing the calibration of the transmitter.

When required to test an ordinary receiver or transmitter the frequency characteristic in the standard is distorted so as to simulate that of the test instrument. The timbre of the two being then identical it is possible to compare the amplitudes accurately.

Messrs. B. S. Cohen, A. J. Aldridge and W. West, of the Research Section, Engineer-in-Chief's Office, read a paper on "The Frequency Characteristics of Telephone Systems and Audio-Frequency Apparatus, and their Measurement" before the Institution of Electrical Engineers at the May meeting. An interesting discussion followed the reading of the paper, in which a number of P.O. engineers took part.

Mr. Donald Murray sends us the following communication:—

TRANSFER OF AGENCY.

I announced some time ago that I had sold my Multiplex printing telegraph business to Creed & Co., Ltd., of Croydon, on the 30th June, 1925.

I have now arranged for the transfer of my agency for the products of the Morkrum-Kleinschmidt Corporation of Chicago, to the Standard Telephones & Cables, Ltd., of Connaught House, Aldwych, W.C.2, on the 31st March, 1926. After that date all enquiries and orders for Morkrum and Kleinschmidt machines and spare parts should be sent to the Standard Telephones & Cables, Ltd.

The Standard Company (formerly the Western Electric Company) has had very large experience in telegraph and telephone work and I have confidence that in transferring the agency to them the interests of my customers will be amply safeguarded and first class service assured to them.

My permanent address is:—

BM/DMRY,
London, W.C.1.

BM/DMRY is my Monomark and letters so addressed will always be forwarded to me wherever I may happen to be.

DONALD MURRAY.

30th March, 1926.

ROYAL CORPS OF SIGNALS DINNER, 1926, AND FORMATION OF A ROYAL CORPS OF SIGNALS DINNER CLUB.

The above Dinner will be held in London on Monday, July 19th.

Officers (Regular, Territorial and Supplementary Reserve) have already been circularised, but owing to lack of recently authenticated addresses it has not been possible to give information either about the Dinner or the formation of the Dinner Club to more than a very small number of the ex-Officers who served in the Signal Service, Royal Engineers, or who were seconded to the Signal Service during the war.

The Honorary Secretary of the Royal Corps of Signals Dinner Club would be glad if any such ex-Officers would kindly communicate their addresses to him c/o S.D.6, The War Office, S.W.1.

Extract from *The Times*, dated 29th May, 1926 :—

"In face of competition from American, German, French, Swedish and Italian concerns, The New Antwerp Telephone & Electrical Works has secured sole rights for the reorganization and exploitation of the Greek telephone and wireless services. The contract is worth about two and a half millions sterling."

Messrs. W. F. Dennis and Co., 70, Queen Victoria Street, E.C.4, are the sole representatives of the above Company in the British Empire.

Research Laboratories of the
General Electric Company, Ltd.,
Wembley.
28th May, 1926.

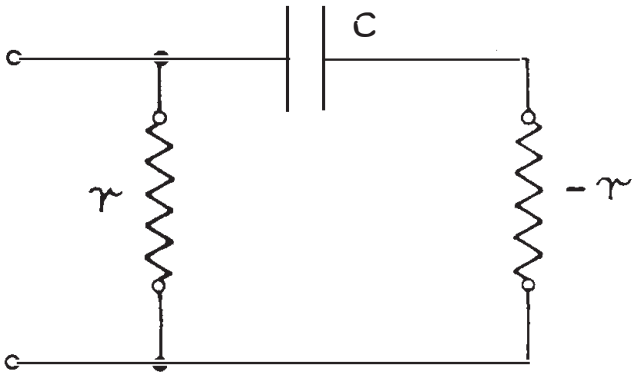
The Managing Editor,
Post Office Electrical Engineers' Journal,
Engineer-in-Chief's Office,
Alder House, E.C.1.

Dear Sir,

In view of the recent discussion in your columns on the Shunted Condenser, the following may be of interest :

An exact solution of the problem of annulling the inductance of a relay coil would be to insert in series with it some circuit or device having an effective negative inductance equal in magnitude to the positive-inductance of the coil.

A circuit having a negative inductance can be constructed by making use of a negative resistance such as the Dynatron or various other thermionic devices.



Assuming that a negative resistance is available consider the simple circuit shown in the Fig., consisting of a resistance r, a capacity C and a negative resistance $-r$.

The impedance of this circuit is

$$\frac{1}{\frac{1}{r} + \frac{1}{-r + \frac{1}{jp\mathrm{C}}}} = \frac{1}{\frac{1}{r} + \frac{jp\mathrm{C}}{1 - jp\mathrm{C}r}}$$

$$= r - jp\mathrm{C}r^2$$

The circuit is thus equivalent to a resistance r in series with negative inductance of value $\mathrm{C}r^2$.

By inserting such a circuit in series with a relay coil and choosing C and r so that $\mathrm{C}r^2 = \mathrm{L}$ the inductance is completely annulled and the growth of current instantaneous.

Further by inter-changing the positive and negative resistances in the Fig. the effective resistance of the circuit becomes negative so that the resistance of the coil can also be annulled and the device in addition becomes an amplifier.

Of course, in practice it would be possible only to approximate to this solution, but since satisfactory negative resistances such as Dynatron have been produced the method should be capable of practical development.

By replacing the capacity by an inductance a negative capacity can be obtained and other more complicated negative impedances can be obtained in a similar way.

Yours faithfully,

A. C. BARTLETT.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

THE following works have been completed :—

Exchange.	Type.	No. of Lines.
Morriston	Auto	320
Ipswich	,,	1560
Swansea Extension ...	,,	440
Barnsley Extension ...	Manual	300
Grangewood Extension ...	,,	1080
Huddersfield Desk ...	,,	—
Hull Toll Extension ...	,,	4 new positions
Ilford Extension	,,	140
Openshaw New	,,	1400
Primrose Hill New ...	,,	4500
Redditch New	,,	340
Speedwell Extension ...	,,	2100
Toll M.F.	,,	130 verticals
Uxbridge Extension ...	,,	220
Auto Strop Razors ...	P.A.B.X.	30
Ashton-u-Lyne Infirmary...	,,	30
Battersea Council ...	,,	70
Birmingham Corporation...	,,	30
Bleachers Association ...	,,	100
Bootle Corporation ...	,,	50
Bradford Infirmary ...	,,	40
Burberry's Ltd.	,,	60
Clark Hunt	,,	40
Collins, Bristol	,,	20
Eastbourne Corporation ...	,,	50
Lambeth Council	,,	50
Lancashire C. Council ...	,,	30
Larkins Ltd.	,,	30
Ledinghams Ltd.	,,	30
Manchester & Salford Co-operative	,,	30
Metal Agencies	,,	70
Middlesex Hospital ...	,,	70
New Hudson	,,	30
North West Road Car ...	,,	30
Owen Owen	,,	60
Pearson Dorman	,,	50
Perfecta Tubes	,,	30
Robinson Bros.	,,	30
Shell Mex (Oxford) ...	,,	30
Spillers & Baker	,,	40
Stelp & Leighton	,,	40
Valor & Co.	,,	30
Wagon Repairs	,,	40
Watney Combe Reid ...	,,	90
Weston-super-Mare Council	,,	30
Yardley & Co.	,,	30

Orders have been placed for the following new Exchanges :—

Exchange.	Type.	No. of Lines.
Chatham Area	Auto	1400
Gillingham	,,	600
Rainham	,,	200
Snodland	,,	200
Strood	,,	400
Foleshill	,,	500
Hanley Area	,,	1080
Burslem	,,	1000
Chesterton	,,	100
Longton	,,	700
Newcastle-under-Lyme ...	,,	500
Stoke-on-Trent	,,	700
Trentham	,,	200
Harrogate	,,	2520
Hereford	,,	800
Macclesfield	,,	1300
Bearsden	Manual	1100
Leek	,,	500
Southend 2nd Relief ...	,,	1100
Armitage & Rigby ...	P.A.B.X.	40
Avonbank Co-operative ...	,,	20
Bootle Corporation ...	,,	50
Barnsley Corporation ...	,,	40
Bristol Times	,,	40
Burberrys	,,	60
Burnley Corporation ...	,,	100
Buxton Lime Firms ...	,,	30
Camberwell Guardians ...	,,	40
Celanese	,,	70
Cullen, W. H. Ltd. ...	,,	30
Dunkelbuhler Ltd. ...	,,	40
Edmonton Guardians ...	,,	100
Fisher & Ludlow	,,	40
Forman & Sons	,,	60
Gaumont Ltd.	,,	50
Glasgow Corporation—		
Town Hall	,,	350
Housing	,,	50
Harrison Ltd.	,,	50
Heywoods Ltd.	,,	60
Kingseat Hospital ...	,,	40
Manifoldia Ltd.	,,	30
Manchester & Salford Corporation	,,	50
Maypole Dairy	,,	80
Mecca Cafe	,,	60
Metal Agencies	,,	70
Middlesex Hospital ...	,,	50
Morris Cars	,,	70
Motherwell Hospital ...	,,	30
Ormrods Ltd.	,,	30
Phillips, J. & A.	,,	30
Pollard & Co.	,,	60
Rudders & Payne... ...	,,	30
Shell Mex (Oxford) ...	,,	30
Shoreditch Council ...	,,	50
Stelp & Leighton	,,	40
Swan & Edgar	,,	100
Transport Workers ...	,,	80
Wm. Walker & Son ...	,,	30
West Bromwich Hospital	,,	30
,, ,, Hallam House	,,	30
West Bromwich & Walsall Corporation ...	,,	40

Orders have been placed for extensions to existing equipments as follows:—

Exchange.	Type.	No. of Lines
Broughty Ferry	Auto	200
Dundee	,,	1000
Sketty	,,	170
Birmingham East ...	Manual	380
Blackpool	,,	1600
Bournemouth	,,	1680
Brixton	,,	1480
Clerkenwell	,,	560
Grangewood	,,	1080
Harrow	,,	1530
Ilford	,,	140
Kingston	,,	1680
Leamington	,,	380
Leith	,,	260
Nelson	,,	260
North	,,	1300

RETIREMENT OF ANDREW FRASER.

Mr. Andrew Fraser, having reached the age of sixty, has retired from the service. A native of Aberdeen, where the stories of meanness come from, he was a characteristic Scot and, acting on the Prime Minister's advice, he remained one to the end. He passed through the stages of Relay Clerk, Second Class Engineer and Assistant Engineer, and for the past two years he was Executive Engineer in the Telegraph Section. For many years he acted for the Department as the examiner of telegraphists for the Overseer's Certificate, and gained for himself a high reputation for absolute fairness. In the early days of the Journal Mr. Fraser contributed a very interesting series of articles on electrical pioneers, and several times since then his writings have graced our pages. He retires with the best wishes of all his engineering colleagues, and we are sure also with the kindliest regard of the staffs of every important telegraph office in the kingdom.

LONDON DISTRICT NOTES.

DURING the quarter ended March 26th, 1926, the number of exchange lines, internal extensions and external extensions provided and recovered, were as follows:—

	Exchange lines.	Internal Extensions.	External Extensions.
Provided ...	11,029	6,982	1,398
Recovered ...	3,162	3,213	636
Net ...	7,867	3,769	762

LONDON DISTRICT NOTES.

External Construction.

Mileage Statistics.

During the three months ended 31st March, 1926, the following changes have occurred :—

Telegraphs.—Nett decrease in open wire of 37 miles and a nett increase in underground of 410 miles.

Telephones (Exchange).—Nett decrease in open wire (including aerial cable) of 416 miles and a nett increase in underground of 38,369 miles.

Telephones (Trunk).—Nett decrease in open wire of 10 miles and a nett increase in underground of 1,090 miles.

Pole Line.—Nett increase of 90 miles, bringing the total to date to 5,362 miles.

Pipe Line.—Nett increase of 160 miles, the total to date being 6,545 miles.

The total single wire mileages at the end of the period under review were :—

Telegraphs	24,766
Telephones (Exchanges)	1,713,362
Telephones (Trunks)	60,998
Spares	56,372

Internal Construction.

New Exchanges.—A new C.B. 10A Exchange was opened at Waterloo on April 19th. The equipment was installed by the Department's staff in a building adjoining the Hop Exchange, which will be afforded much needed relief.

A new C.B.1 Exchange was opened at Primrose Hill on May 13th. The equipment was installed by Messrs. Ericsson's Manufacturing Company, and will accommodate 4,500 lines.

A C.B.10 Exchange, known as "Kelvin," was brought into use on May 19th. The Exchange, which was installed by the Department's staff, is located in the building erected for the accommodation of the Western Automatic Exchange.

Two new C.B.1 Exchanges are in course of construction by the General Electric Company at Rodney (Walworth), and Battersea. The Exchanges will accommodate 3,700 and 5,490 subscribers respectively.

The *S.M.T. Trial Equipment* at City Exchange has been completed by the A.T.M. Company, and is in course of being tested out.

Progress is being made with the construction of the Holborn Mechanical Tandem, Holborn Automatic, and Bishopsgate Automatic Exchanges.

Closing of Bank Exchange.—The Bank Exchange was closed on June 5th, the subscribers being transferred to the Exchanges serving the areas in which the subscribers' premises are located.

TELEGRAPHS.

The Jersey circuit has been fitted with modern Creed apparatus and similar apparatus has been installed in connection with the Norwegian circuits which are now to be worked from the Central Telegraph Office instead of by a Cable Company.

There are now four types of Creed in use: (1) Pneumatic, with air pressure in common; (2) Pneumatic self-pumping; (3) Wholly electric, and (4) Electric modified.

Apparatus of the Wheatstone and Creed types has been installed in appreciable quantity in connection with the Wireless Beam Stations, and the accommodation for Wireless work is being taken up rapidly.

Teletypes are still increasing and two patterns—typewheel and typebar—are now in use. These instruments are being used for Private Wires as well as Public Telegraphs.

MR. JAMES HAY THOW.

The death of Mr. J. H. Thow, Assistant Superintending Engineer, London District, has to be recorded with great regret. His numerous friends in the Engineering Department were shocked to receive, on the morning of April 22nd, the news that he had passed away suddenly and unexpectedly after a short illness. Mr. Thow, who was in his 59th year, was on duty, apparently in the best of health, up to Easter, when he met with a slight accident, but this was not thought to be serious. He was seen by some of his colleagues very shortly before his death, and then seemed to be in good spirits and making rapid steps towards recovery.

Mr. Thow entered the Department's service as a Telegraphist at Glasgow in October, 1884, and was transferred in March, 1892, to the Engineering Branch, in which Department he passed through the grades of Junior Clerk, Second Class Clerk and First Class Clerk prior to 1898, when he became a Second Class Engineer. In 1902 he came to London as a First Class Engineer in the (then) South Metropolitan District, and took charge of the Ealing Exchange Area when the Ealing Exchange was opened in 1904. After some years in charge of the Western Exchange Section he was engaged for a short time in the Technical Section of the Superintending Engineer's Office, and was then transferred to the C.T.O. Section. In this Section he took a very active interest in the Dudley pneumatic tube (continuous suction low

vacuum) system. He made many attempts to solve some of the difficulties inherent in the street tube system in London, but his experiments came to a close on his promotion to Assistant Superintending Engineer in the South Midland District, with headquarters at Reading.

During the War, Mr. Thow took special charge of the installation and maintenance of works in connection with Air Defence in the South Midland District. After the War, extensive underground works, including the South Midland District portion of the London-Bristol, London-Southampton, and a number of the London Toll cables, were mainly under his control.

In 1922 he was transferred to the London Engineering District where he dealt more particularly with telegraph matters, buildings and the technical training of the minor staff.

His interests and hobbies were many. At Ealing he was well known in local circles and for many years was a member of the choir of the Parish Church. On his return to London from Reading he lived at Tulse Hill and became a member of the Church Choir there. In all, his services as a chorister extended to fifty years.

Mr. Thow was a very capable amateur mechanic and was skilled in the use of tools. He was also expert in cabinet making and wood working, and his work would be creditable to a professional craftsman.

Our late colleague possessed an exceptionally bright and cheerful personality, and was popular with all grades of the staff. He was a devoted husband and father, and those who knew him intimately mourn the loss of a sincere friend. An indication of the love and respect of those with whom he came in contact is contained in the fact that upwards of two hundred letters of condolence were received by his family.

R.A.W.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

ELECTION OF COUNCIL FOR THE YEAR 1926-27.

The constitution of the new Council will be as follows:—

Chairman—Mr. A. L. DeLattre.

Honorary Treasurer—Mr. B. O. Anson.

Representing Staff of the Engineer-in-Chief's Office—
Mr. C. J. Mercer, and Mr. E. J. Wilby.

,, Executive Engineers—
London: Mr. A. Wright.
Provinces: Mr. W. J. Rolfe.

Representing Assistant and Second Class Engineers—
London: Mr. J. H. Bell.
Provinces: Mr. C. E. Morgan.
,, Chief Inspectors—
London: Mr. W. A. B. Romain.
Provinces: Mr. A. S. Carr.
,, Clerical Staff—
London: Mr. E. T. Larner.
Provinces: Mr. A. W. Lines, and Mr. H. Longley.
,, Inspectors—
London: Mr. C. W. Messenger.
Provinces: Mr. R. P. Collins.
,, Draughtsmen—
London and Provinces: Mr. J. Millet.
Secretary—Mr. R. V. Hansford.

LOCAL CENTRE NOTES.

LONDON CENTRE.

SESSION 1925-26.

It is satisfactory to record that increasing interest in the activities of the Institution has been shown. Six Ordinary Meetings, the Annual General Meeting, and five Informal Meetings were held.

The programme for the Ordinary and Annual General Meetings was as follows:—

13th October, 1925, a Lecture by Major A. G. Lee, M.C., B.Sc., M.I.E.E., on "The work of the Wireless Experimental Section."

24th November, 1925, a paper by Harvey Smith on "The Problem of Flexibility in Subscribers' Cable Distribution."

8th December, 1925, a paper by Capt. H. Hill, B.Sc., M.I.E.E., on "The Engineering Aspect of Telephone Exchange Accommodation."

12th January, 1926, a paper by W. Layton on "Precision Testing in the London Engineering District."

9th February, 1926, two papers by Capt. N. F. Cave-Brown-Cave, B.Sc., M.I.E.E., on (*a*) "Testing of Secondary Cells," and (*b*) "Torch Blowing Lamps."

9th March, 1926, a paper by Messrs. E. S. Ritter, D.F.H., A.M.I.E.E., and G. P. Milton on the "Testing of Telephone Circuits and Apparatus with Alternating Currents."

1st June, 1926 (Annual General Meeting), a paper by Messrs.

G. F. O'dell, B.Sc., A.K.C., M.I.E.E., and W. W. Gibson on "Automatic Trunking in Theory and Practice."

Most of the papers have been recommended for printing, but some time must elapse before the printed copies are available. For the convenience of members a typewritten copy of each paper has been deposited with the Librarian.

The subjects for the Informal Meetings were as follows:—

October 27th, 1925. Notes on "American Telephone Industry—an Outline of its Development, Organisation and Control," prepared by Mr. W. Day, M.I.E.E. [These notes have been printed in the May, 1926, issue of the *Telegraph and Telephone Journal*.]

December 15th, 1925. Notes on "Pipe Laying by Magnall Irving Thrust Boring Apparatus in London," prepared by Mr. Arthur Miller.

January 19th, 1926, was reserved for the continued discussion on Mr. Harvey Smith's paper on "The Problem of Flexibility in Subscribers' Cable Distribution."

January 26th, 1926. Notes on "Transmission Values of Circuits in the London Area," prepared by Mr. J. S. Elston.

February 23rd, 1926. Notes on "Minor Staff—Recruitment, Training and Advancement," prepared by Mr. W. A. Williams. [A copy of these notes has been deposited with the Librarian.]

Visits: Arrangements were made for a visit to the Sterling Telephone and Electric Co., Ltd., Works at Dagenham, Essex, and to the Standard Telephones and Cables, Limited, Works at New Southgate. The development of Automatic Telephones and Wireless Broadcasting made these visits particularly interesting and it was unfortunate that so many of the members who had notified their intention of visiting either or both of these works were prevented by the exigences of their official work. The Committee would like to take the opportunity of thanking the Managing Directors and their staffs for the excellent programmes arranged for the visitors.

The members of Committee for the 1926-27 Session are as follows:—

Chairman—Major A. G. Lee, M.C., B.Sc., M.I.E.E.
Vice-Chairman—Mr. J. W. Atkinson, M.I.E.E.
Representing Staff Engineers at Headquarters—
Mr. P. T. Wood.
,, Executive Engineers—
Mr. F. Blick, A.M.I.E.E., and Mr. J. Cowie, M.I.E.E.
,, Assistant Engineers—
Mr. W. W. B. Crompton, A.M.I.E.E., and Mr. W. Dolton, M.I.E.E.

Representing Chief Inspectors—
Mr. J. Hargreaves, (vacancy).
,, Inspectors—
Mr. D. C. Maddocks, and Mr. A. Miller.
,, Draughtsmen—
Mr. H. Taylor.
,, Clerical Staff, London Engineering District—
Mr. E. T. Larner, A.I.E.E.
,, Engineering Staff, South Eastern District—
Mr. W. J. Jenkins.
,, Clerical Staff, South Eastern District—
Mr. P. J. Dodgson.
Local Secretary—Mr. F. W. Friday.

On the 11th May, Messrs. G. F. O'dell and W. W. Gibson read a paper on "Automatic Trunking in Theory and Practice." The following is a synopsis of the paper:—Introduction. Divergence between theory and practice. Difference between manual and automatic exchange traffic. Use of the theory of probabilities—its value and the conditions necessary for making best use of it. Traffic carried by each switch in a simple group calculated and measured. Method of estimating theoretically the traffic carried by a grading, comparison of this method with results of practical tests. Method of taking records in automatic exchanges.

(1) Measurement of congestion or last contact traffic.
(2) ,, of lost calls or overflows.
(3) ,, of total calls.
(4) ,, of traffic carried by a group of switches.
(5) Recording instruments.

A most interesting discussion followed.

R.T.R.

SCOTLAND WEST CENTRE.

For our March fixture the lecturer for the day was Captain Hill, B.Sc., M.I.E.E., of the Engineer-in-Chief's Staff, the subject being "The Engineering Aspect of Telephone Exchange Accommodation." The attendance was unusually large, being augmented by visitors from the staffs of the District Managers and from the Postmaster's staff. It is understood that the paper is being read before other Centres, and consequently it is unnecessary here to go into any details of the subject, beyond stating that the paper proved of great interest to the audience—an interest much enhanced by the style of delivery. The demand for copies of the paper could not be met.

The last item on the programme for Session 1925-26 was reached on 19th April, when three films were shown—

(1) Aiding the Art of English Conversation.
(2) Creating the Instruments of Speech.
(3) The Audion.

The first two films illustrated operations in the manufacture, handling and laying of cables; also various stages in the production of telephone equipment and Wireless Apparatus. The third film, "The Audion," illustrated in detail the action taking place inside the Thermionic Valve. There was a large turn-out of members, and of visitors representing kindred institutions. The films were very much appreciated, and the thanks of the local centre are due to the lenders of the films, namely, Standard Telephone and Cables, Limited (formerly Western Eelectric Company, Ltd.).

Many members of the Engineering Department who were at one time associated with the Glasgow Telegraph Instrument Room or who have in the past been attached to the Scotland West District will regret to learn of the passing of their old acquaintance, John Paxton, whose death took place on the 8th of April. Mr. Paxton had been in failing health for some considerable time, but the end, when it came, was very unexpected.

Mr. Paxton joined the Engineering Department towards the end of 1902 and was appointed to Higher Clerical rank in 1920. His death has caused keen regret among his colleagues of all ranks in the District with which he was connected for a period of over 24 years.

NORTH WALES CENTRE.

The fourth meeting of the Session was held at the Shrewsbury Technical School on the 13th January, 1926, when Mr. A. E. Stollard read a paper on "The Relay System of Automatic Switching—Private Branch Exchanges." Mr. Stollard traced the progress of telephonic communication from the original invention by Dr. Graham Bell and exhibited a series of slides showing early types of switchboards and proceeded from this to a description of the components of the relay automatic system and of the design and characteristics of the relay. The paper concluded with a description of the Fleetwood Relay Automatic Exchange.

At the fifth meeting which was held on the 1st February, 1926, Captain H. Hill, of the Engineer-in-Chief's Office, read his paper on "The Engineering aspect of Telephone Exchange Accommodation." The paper has already been referred to in these columns and it was followed by a very full discussion and a hearty vote of thanks to Captain Hill.

The sixth and final meeting of the Session was held on

Wednesday, the 10th of March, when Messrs. R. S. Dacombe and J. T. B. Donnellan read a paper entitled "Plant Records, Their Preparation and Use." The paper was illustrated by slides and diagrams and contained a very full and interesting description of the plant records of various kinds which are maintained under the official instructions. Slides illustrating the official route maps, vandyked plans, cable records, mileage plans, pole diagrams, etc., etc., were exhibited and their usefulness explained. In the discussion which followed many complimentary references were made to the manner in which the drawing office work at Birmingham is carried out and to the assistance which the very complete plant records afford the officers engaged on development and rearrangement schemes.

The Session which has just ended has been a very successful one as regards attendance and interest in the papers. The former has varied from between 70 to 80 and the discussions have not infrequently had to be hastily concluded to allow members to catch their trains homeward.

Robert Gardner Masaroon.

Robert Gardner Masaroon, who is well known throughout the Post Office Engineering Department, retired from the position of Assistant Superintending Engineer of the North Wales District on the 26th January last after 44 years' service to the State in various capacities.

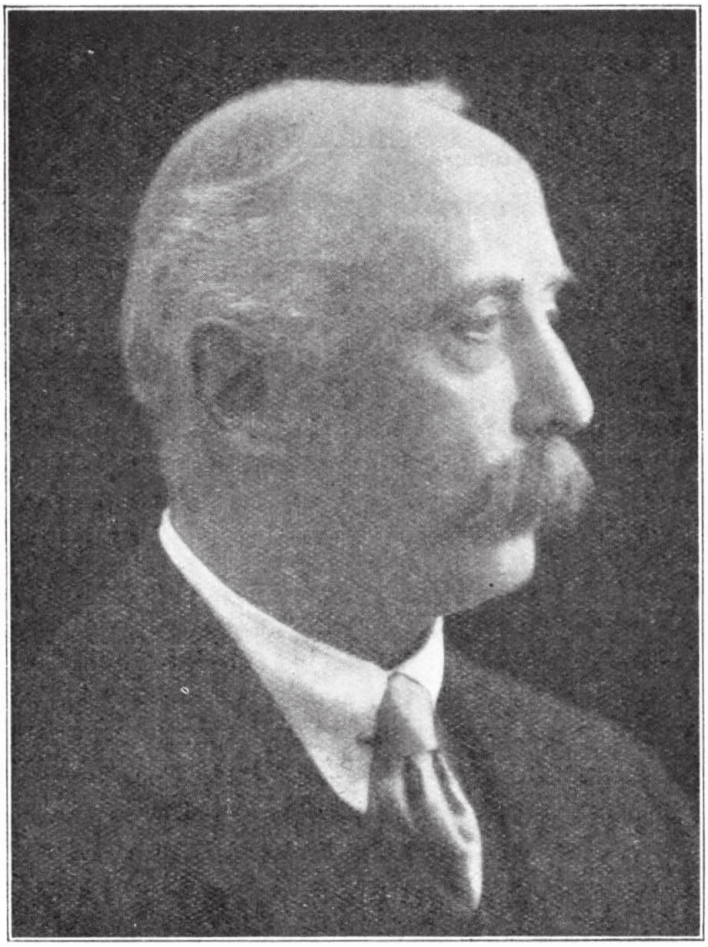
After serving for two years at sea, during which he made the famous trip round Cape Horn to California and back in an old wind-jammer, he entered the Post Office service as a telegraphist at Londonderry in 1882. A year later he joined the Telegraph Battalion of the Royal Engineers, subsequently serving in the Egyptian campaign of 1885. He was invalided home to England and continued his military service in the old Southern Engineering District.

Mr. Masaroon's reputation as an efficient administrator was such that during the South African war, when all the Royal Engineer officers were withdrawn for active service, he was placed in charge of the South-West portion of the Southern District as Acting Superintending Engineer. The manner in which he carried out this duty elicited the special thanks of the Engineer-in-Chief.

In 1904, on the completion of his military service, Mr. Masaroon was appointed 1st Class Engineer in the Post Office Engineering Department, in which capacity he served at Bristol until 1909, when he was promoted, after a competitive examination, to the position of Assistant Superintending Engineer. After a short period of service in Ireland he came to the North Wales

District, where he remained until his retirement in January last. This, very briefly, is the record of Mr. Masaroon's meritorious career.

It is no mere platitude to say that Mr. Masaroon's retirement leaves a distinct gap in the North Wales District; and it is also regarded as a personal loss not only by his engineering colleagues, but also by his many friends in other Departments with whom he came into official contact. His long and varied experience had filled his mind with precedents, which enabled him to suggest



R. G. Masaroon

ways and means of removing difficulties and getting things done, and his chief characteristic in his official duties was his readiness to place his experience at the service of his subordinates of all ranks.

Those of his more intimate colleagues have a very warm regard for him for his personal qualities, and they cherish the hope that there may be many opportunities of meeting him at Weston-super-Mare, his chosen place of retreat, where he will have more leisure

to devote to his well-stocked library, which he has gathered together through a long course of years.

It has been said that any man who has led an active life has at least one good book in his head if he would only write it, and the saying should certainly be true of Mr. Masaroon, but instead of writing a book he prefers to tell his experiences to his friends orally, and it is his delightful table-talk which has always made him the best of good company. Both officially and personally he leaves many pleasant memories behind him.

At a recent Staff gathering a presentation of a barometer and 3-valve wireless set was made to him, and representatives of all grades of the staff expressed their hearty good wishes to him and Mrs. Masaroon for a happy retirement.

We deeply regret to record the death of Mr. A. E. Giffen, Executive Engineer, Hanley, which took place on the 3rd of February. Mr. Giffen, who had been ill for some months previously, was 55 years old. He entered the service as a Sorting Clerk and Telegraphist at Glasgow in 1886 and was, later, transferred to the Engineering Department as a junior clerk. He became, successively, Sub-Engineer, Engineer 2nd Class, Engineer 1st Class, and Executive Engineer, his various Districts being North Wales, Ireland, Midland, Metropolitan Central, South Midland, and finally again, North Wales, where he was Sectional Engineer at Stafford and Hanley for over 17 years. In him the Department had a very efficient and zealous officer who combined very highly developed powers of organization and control with unfailing courtesy and consideration towards his subordinates. His personal qualities were appreciated not only by his colleagues but by his fellow citizens in the Potteries area, where he took a full part in the local Engineering associations and in the local and national organizations connected with the church to which he belonged. G.R.

NORTHERN CENTRE.

On the 17th March Capt. H. Hill, B.Sc., M.I.E.E., of the Engineer-in-Chief's Office, delivered a very instructive and informative lecture on "The Engineering Aspect of Telephone Exchange Accommodation," before a well attended meeting. The paper was very well received and the discussion, which had to be curtailed owing to time considerations, was replied to in a very able manner. A vote of thanks to Capt. Hill was carried with hearty acclamation.

The members of the Centre were invited by The Junior Institu-

tion of Engineers to a show of films on the 19th March, illustrating the manufacture of Morris Cars and Dunlop Tyres.

Mr. J. H. Bell, A.M.I.E.E., of the London Engineering District, made a welcome return visit to Newcastle on the 7th April, when he gave a blackboard Automatic lecture, his subject being the "Final Selector for P.B.X. Groups." Mr. Bell is an experienced lecturer and employs a unique method of illustrating his subject by building up diagrams step by step in a simple and absorbing manner on the blackboard.

The meeting was very enjoyable and instructive, and the members voiced their thanks to the lecturer adequately.

The Committee for next Session has been selected as follows:—

Chairman—J. R. M. Elliott.
Vice-Chairman—F. G. C. Baldwin.
Representing Executive Engineers—G. A. Peck.
,, Clerical Staff—J. A. Motyer.
,, Assistant Engineers—C. P. Kay.
,, Chief Inspectors—W. Weightman.
,, Draughtsmen—S. J. Millett.
,, Inspectors—A. H. Wade.
Local Librarian—J. Stark.
,, Secretary—A. C. Smith.

NORTH WESTERN CENTRE.

The closing meeting of the 1925-26 Session was held in the Lecture Hall of the Preston Scientific Society, Fishergate, Preston, on the 29th March, 1926, when a paper entitled "Amateur Wireless Stations" was read by Mr. H. Horrocks. J. M. Shackleton, Esq., M.I.E.E., the newly appointed Superintending Engineer of the North Western District, presided and was accorded an ovation upon taking the Chair. Mr. Horrocks, in the course of an interesting paper dealt chiefly with the conditions which would likely be found by an officer called upon to make an inspection of an Amateur Wireless Station and touched upon the following points:—Permits, Aerials, Wavemeters (Buzzer and Heterodyne), Transmitting Circuits, Receiving Circuits, etc., and related some actual experiences which he had had in his capacity as inspecting officer. The paper was illustrated by an excellent set of lantern slides.

The 1925-26 Session has been most successful. Six meetings have been held, and a visit has also been paid to the new super power station of the Preston Corporation. There has been a nett increase of 11 in the membership during the year, there have been no resignations and the total of membership of the Centre now stands at 101. There has been a marked increase in the average

attendance at the meetings and a point worthy of mention is the helpful discussions which have taken place.

Local Organization, Session 1926-27 :—

Chairman—J. M. Shackleton, Esq.
Vice-Chairman—J. Sinclair Terras, Esq.
Committee—Messrs. W. J. Rolfe, W. Beattie, C. Coward, R. B. Austin, E. Hopper, and H. S. Turner.
Local Librarian—Mr. H. Howarth.
,, Secretary—Mr. D. Barratt.

SOUTH LANCS. CENTRE.

It is with extreme regret that we have to record the death of Mr. J. Cardoc Jones, Assistant Engineer, Manchester, in his 57th year.

All who knew him during his varied career will regret the passing of a highly respected colleague and a well informed and zealous servant of the Department.

SOUTH WALES CENTRE.

Annual Report.

As no District Notes have appeared in the Journal for a long time, I shall be obliged if you will have the following published :—

The local committee for the 1926-7 Session has been elected as follows :—

Executive Engineers—Mr. W. Scott.
Assistant Engineers—Mr. W. H. Lane.
Chief Inspectors—Mr. H. W. Gifford.
Inspectors—Mr. S. H. Pendleton.
Clerical—Mr. A. G. Packer.
Draughtsmen—Mr. E. W. Thomas.
Local Secretary—Mr. F. J. B. Clarke.

The position of Local Secretary, very ably filled by Mr. E. C. J. Badger, has been relinquished by him owing to his retirement from the Department's service next August.

Six meetings were held during the Session 1925-6 and the following papers were read :—

"Notes on Cable Balancing." Mr. J. F. Stewart, Haverfordwest.
"The Engineering Aspect of Telephone Exchange." Capt H. Hill, E.-in-C.'s Office.
"The Training of an Engineering Inspector." Mr. H. W. Gifford, Cardiff.
"Some points on Trunking in Automatic Exchanges." Mr. G. F. O'dell, E.-in-C.'s Office.
"Inspection of Amateur Wireless Stations." Mr. H. B. Somerville, E.-in-C.'s Office.
"Newport Repeater Station." Mr. S. H. Pendleton, Newport.

After the reading of the last paper a visit was made to the Repeater Station, which was greatly appreciated by the members.

A. HOARE.

SOUTH MIDLAND CENTRE.

The 57th meeting on 31st March, 1926, was the first of the Centre held in the College after its elevation to the dignity of a University. The attendance numbered 63.

The proposal of Mr. Halton that the Vice-Chancellor be congratulated in the name of the Centre on the grant of a charter conferring University status was endorsed by all the members present and the Secretary was instructed accordingly.

Mr. H. C. McCormack then commenced his paper :—

"Organisation of a Superintending Engineer's Office."

This was arranged under seven headings—historical note, accommodation, arrangement of work, staff provision, training, annual leave and inspections. The ideals which should be sought when providing or selecting accommodation for a District Headquarters were set out and the fittings required for use in the various rooms were described.

Under "arrangement of work" the standard division of the functions between the groups was examined, minor differences existing in the South Midland District explained and a method was outlined which would reduce the time occupied in dealing with registered papers.

Mr. McCormack identified himself with the benevolent policy of the encouraging angels when criticism of imperfect work was justified.

Substantial economies which have followed the clerical reorganisation of 1922 were described and the opinion advanced that an Accountant or Principal Clerk should be appointed in each District and a second Assistant Superintending Engineer in the larger Districts.

In discussing the training of the clerical force, generalisation as opposed to specialisation was favoured and plans for the vocational education of the District Headquarters' staff were disclosed.

The paper concluded with details of the inspecting duties handed down in recent years to lower ranks by Superintending Engineers and their assistants.

The discussion which followed did not lack animation and although the unprecedented number of nine spoke, several sheaves of notes were being waved at the Chairman when, as the usual hour of closing the meeting had passed, he asked Mr. McCormack to reply. The nine successful in the competition to catch the

Chairman's eye were Messrs. Harry, Halton, J. S. Brown, Lines, Roach, Beetlestone, Dwyer, King and Roberts and the lecturer succinctly disposed of the many questions asked and views expressed.

Mr. McCormack was thanked for his contribution by enthusiastic applause.

Seventy-four were present at the 58th meeting, the last of the 1925-6 Session which took place on the 28th April.

The members and visitors stood in silence as a mark of respect to the memory of the late Mr. J. H. Thow, onetime Vice-Chairman, and of Mrs. Robb, wife of a former Chairman of this Centre. Mr. Thow and Mrs. Robb died during April.

The certificates gained in the 1925-6 Essay Competition were presented to:—Mr. C. A. Maggs, Mr. A. E. W. Maslin, Mr. F. W. Dye, and Mr. C. L. Wicks, the first two of whom had each received a cheque at an earlier date. The Chairman, in handing over the certificates congratulated the staff of the South Midland District on its splendid record in gaining 7 out of a total of 20 awards made in connection with the three competitions held to date.

The paper read at the meeting was entitled:—" The Duties of an Inspector," by Mr. F. D. Traviss.

The lecturer first dealt with the general responsibilities of Inspectors and passed on to give his views about the training of workmen. The U.C.C. and U.M.C. systems came under notice, two posers within the construction costing system were enunciated and in connection with maintenance the question of faults was discussed.

The preparation of estimates was described under the headings of overhead and internal and the engineering work required before a new rural exchange was ready for opening was explained. Mr. Traviss dealt with the organisation necessary in arranging for the supply of stores for works and detailed the records set up.

Advice Note work and pole spottings were touched upon and the system adopted for the filing of W.O's, A.N's and Maps was described. The routine of recording, with special reference to A.N's route cards and surplus stores, was outlined.

The paper ended with the lecturer's views on the question of the grade whom he considered should be employed in the negotiation of wayleaves.

The last minutes of the Session were profitably occupied in answering the questions put by Major Harris, Messrs. Stevenson, Peck, Dwyer, W. L. Taylor, Capt. Horton, Messrs. Lewis, Atkins, Wakefield, Halton, Campbell and Dickinson.

The Chairman, in thanking Mr. Traviss, stated that the record number of questions had demonstrated the great interest which the audience had in the subject of the lecture.

The past Session has been a successful one, the average attendance at the seven meetings has been 64. The number of the offers received of papers to be read during the next Session is most encouraging.

A.W.L.

BOOK REVIEWS.

"Elementary Electrical Engineering," By O. R. Randall London: Sir Isaac Pitman & Sons, Ltd. Pps. 233. 5*s*. nett.

This book should prove useful to those taking a laboratory course in Electrical Engineering. It deals with the subject essentially from a practical standpoint, but contains enough theory to make it interesting and intelligible without at the same time being too mathematical.

Useful chapters appear on instruments, D.C. motors and generators and simple A.C. circuits. The subject of secondary cells, however, which nowadays is of special interest to all P.O. Engineers concerned with the installation and maintenance of small power plants receives scant treatment, as do also the chapters on electric lamps and arcs.

H.C.J.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Pennington, W. ...	Executive Engineer, London District.	Asst. Suptg. Engr., London District.	18-5-26
Finlayson, W. J. ...	Assistant Engineer, N.West District.	Executive Engineer, N.West District.	25-3-26
Sharpley, A. J. ...	Assistant Engineer, E.-in-O. Office.	Executive Engineer, E. District.	1-4-26
McMullin, J. F. ...	Assistant Engineer, S.Wa. District.	Executive Engineer, S.Mid. District.	6-4-26
Gibbon, A. O. ...	Assistant Engineer, E.-in-O. Office.	Executive Engineer, E.-in-C. Office.	3-4-26
Fleetwood, H. O. ...	Assistant Engineer, Met. Power District.	Executive Engineer, Met. Power District.	To be fixed later.
Croker, J. R.	Assistant Engineer, E. District.	Executive Engineer, S.E. District.	do.
Escott, H.	Assistant Engineer, S.Lancs. District.	Executive Engineer, S.Lancs. District.	do.
Bedford, J. G. ...	Prob. Assistant Engr., E.-in-C. Office.	Assistant Engineer, E.-in-C. Office.	1-4-26
Missen, E.	Prob. Assistant Engr., E.-in-C. Office.	Assistant Engineer, E.-in-C. Office.	1-4-26
Chinn, W. E.	Prob. Assistant Engr., E.-in-C. Office.	Assistant Engineer, E.-in-C. Office.	1-4-26

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date.
Romain, W. A. B. ...	Chief Inspector, London District.	Assistant Engineer, London District.	27-3-26
Keir, A. D.	Chief Inspector, Scot.E. District.	Assistant Engineer, Scot.W. District.	To be fixed later.
Parker, T.	Chief Inspector, N.E. District.	Assistant Engineer, S.E. District.	do.
Green, H. W. ...	Chief Inspector, N.Wa. District.	Assistant Engineer, N.Wa. District.	do.
Richards, T.	S.W.1, N. District.	Inspector, N. District.	16-11-25
Luxton, W. G. ...	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Turner, H. M. ...	Prob. Inspector, S.Lancs. District.	Inspector, S.Lancs. District.	12-1-26
Swift, R. E.	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Knowers, A. D. V. ...	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Brett, S. I.	Prob. Inspector, London District.	Inspector, London District.	12-1-26
Potts, E.	,,	,,	12-1-26
Chew, W. G. N. ...	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Franklin, R. H. ...	,,	,,	12-1-26
Berkeley, G. S. ...	,,	,,	12-1-26
Hibberd, W. A. ...	,,	,,	12-1-26
Harvey, E. D. ...	Prob. Inspector, London District.	Inspector, London District.	12-1-26
Phillips, R. S. ...	Prob. Inspector, E.-in-C. Office.	Inspector, E.-in-C. Office.	12-1-26
Ackerman, H. M. W....	Prob. Inspector, London District.	Inspector, London District.	12-1-26
Penn, H. A.	Prob. Inspector, London District.	Inspector, London District.	12-1-26
Tester, H. F.	S.W.1, London District.	Inspector, London District.	28-2-26
Murphy, J. C. ...	S.W.1, Scot.W. District.	Inspector, Scot.W. District.	18-4-26
Blackman, R. W. ...	S.W.1, E.-in-C. Office.	Inspector, E.-in-C. Office.	1-3-26
Thorpe, L.	S.W.1, S.E. District.	Inspector, S.E. District.	17-2-26
Allen, J. L.	,,	,,	22-6-25
Lock, G. R.	,,	,,	8-3-26
Stead, A. D.	,,	,,	14-12-25
Sandford, W. H. ...	,,	,,	17-5-26
Wallis, H. W. ...	,,	,,	24-5-25
Eaves, A.	,,	,,	14-5-26
Seach, G. E.	S.W.1, E. District.	Inspector, E. District.	1-2-26
Gilbert, F. W.... ...	,,	,,	26-1-26
King, R. R.	,,	,,	20-3-26
Partington, B. G. ...	S.W.1, S.Lancs. District.	Inspector, S.Lancs. District.	19-10-25

APPOINTMENTS.

Name.	Grade.	Date.
Richards, E. M. ...	Probationary Assistant Engineer, Testing Branch.	22-3-26
Stratton, J.	,,	1-4-26

STAFF CHANGES.

TRANSFERS.

Name.	From	To.	Date.
McCormack, W. ...	Executive Engineer, S.Lancs. District.	Executive Engineer, S.E. District.	To be fixed later.
Jackson, J. M. ...	Assistant Engineer, E.-in-C. Office.	Assistant Engineer, N.W. District.	14-3-26
Snell, W. S.	Assistant Engineer, E.-in-C. Office.	Assistant Engineer, S.W. District.	16-5-26

RETIREMENTS.

Name	Grade.	District.	Date.
Whitehead, J.	Executive Engineer,	Eastern District.	31-3-26
Brown, J. S.	Executive Engineer,	S.Mid. District.	31-3-26
Fraser, A.	Executive Engineer,	E.-in-C. Office.	2-4-26
Barradell, D.	Chief Inspector,	S.E. District.	29-4-26
Sargeant, A. J. ...	Chief Inspector,	London District.	28-5-26

DEATHS.

Name.	Grade.	District.	Date.
Thow, J. H.	Asst. Suptg. Engr.,	London District.	22-4-26
Jones, J. C.	Assistant Engineer,	S. Lancs. District.	27-3-26
Antliff, A. E.	Inspector,	S.W. District.	30-4-26
Barker, W. L. ...	Inspector,	London District.	28-2-26

CLERICAL ESTABLISHMENT.

APPOINTMENTS AS CLERICAL OFFICER.

Name.	District.	Date.
Griffiths, W. J.	South Western.	23-2-26
Wheater, J.	North Midland.	21-3-26
O'Carrigan, J. T. ...	London.	7-3-26
Laird, D. S.	Met. Power.	21-3-26

PROMOTIONS.

Name.	Grade.	Promoted to	Date
Tennant, T. M. ..	Executive Officer, E.-in-C. Office.	Staff Officer, E.-in-C. Office.	1-5-26
Impett, C. W. ...	Clerical Officer, E.-in-C. Office.	Executive Officer, E.-in-C. Office.	1-5-26

RETIREMENTS, ETC.

Name.	Grade.	District.	Date.	Remarks
Fisher, H. G.	Staff Officer.	E.-in-C.O.	30-4-26	Retired.
Jackson, R.	Clerical Officer.	London.	13-5-26	,,
Bell, A.	,,	Scot.W.	25-3-26	,,
Paxton, J.	Higher Clerical Officer.	Scot.W.	8-4-26	Deceased.
Bowkett, C.	Clerical Officer.	N.Wales.	5-5-26	,,

BOARD OF EDITORS.

B. O. ANSON, M.I.E.E., Chairman.

E. H. SHAUGHNESSY, O.B.E., M.I.E.E., M.I.R.E.
Lieut.-Col. A. C. BOOTH, M.I.E.E.
J. W. ATKINSON, M.I.E.E.
H. LONGLEY.

W. CRUICKSHANK, M.I.E.E., Managing Editor.
J. J. McKICHAN, Assistant Editor, A.M.I.E.E.

COMMUNICATIONS.

All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, Alder House, London, E.C.1.

Binding covers and copies of the Contents for Vol. 3 to 18 are available, and may be obtained from the local agents for 1*s.* 6*d.* and 3*d.* respectively. Subscribers can have their copies of Vol. 18 bound, with index included, at a cost of 3*s.* by sending the JOURNALS to the local agents. Orders should indicate whether the original binding with black lettering, or the later pattern in gold, is required.

The price of the JOURNAL is 1*s.* 6*d.* (1*s.* 9*d.* post free) per copy, or 7*s.* per annum, post free. All back numbers 2*s.* each.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

Officers of Colonial and Foreign Telegraph Administrations who are engaged in Electrical Engineering Works may be admitted as Colonial and Foreign Corresponding Members respectively, after application.

Subscription payable annually in advance on 1st April in each year:

Colonial Members	... ...	£1 0 0
Foreign ,,	... ...	£1 10 0

These sums include Annual Subscription to the Journal of P.O. Electrical Engineers and the supply of all Professional Papers issued during the period covered by subscription.

Forms of application for Colonial and Foreign Membership can be obtained on application to

The Secretary,
Institution of P.O.E. Engineers,
G.P.O., Alder House, E.C.1.

ESSAY COMPETITION, 1925-26.

The Judges have reported to the Council that the Prize Winners in the recent Essay Competition, arranged in order of merit, are as follows:—

1. S. H. JOHNSON, External Section, Birmingham.
   "The Technical Certificates—Why, and how to acquire them."
2. C. A. MAGGS, Repeater Station, Marlborough.
   "The Vacuum Tube Amplifier and its application to Telephone Repeater Circuits."
3. A. W. T. BALDWIN, City External Section, London.
   "Secondary Batteries."
4. A. E. W. MASLIN, Oxford Section.
   "Telephone Development in Rural Districts."
5. J. E. WRIGHT, Research Section, E.-in-C.O.
   "Insulating Materials."

The number of entries this year was 71, a great increase over the corresponding number of last year. The Judges report that the average quality is higher than last year, and, on their recommendation, the Council has decided to award Certificates of Merit to the following five competitors who were next in order of merit:—

6. H. SATTERTHWAITE, Fordrough Lane Depôt, Birmingham.
   "Testing new Stationary Secondary Cells."
7. A. J. ALLISON, South East External Section, London.
   "Coder Call Indicator."
8. F. W. DYE, Guildford Section.
   "The Testing of Lines and Apparatus at Telephone Speech Frequencies."
9. R. D. SUTTER, Greenock, Scot. W. District.
   "Section Stock."
10. C. L. WICKS, Repeater Station, Marlborough.
    "Telephone Repeater Station Power Plant."

R. V. HANSFORD,
Secretary.

April, 1926.

Dry Core Cables

Nothing in the world is infallible, but you get very near to infallibility when you

Let

HENLEY CABLES

carry the current.

We manufacture every type of Aerial Cable—Bare, Single, Double and Triple Braided, with ordinary compounding or our special long life "**Endural**" compound.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, LIMITED.
HOLBORN VIADUCT, ∴ LONDON, E.C.1.

780

INDEX TO ADVERTISERS.

	PAGE
Automatic Telephone Mfg. Co., Ltd	iii
British L.M. Ericsson Mfg. Co., Ltd.	v
Creed & Co, Ltd.	viii and ix
Henley's, W. T., Telegraph Works Co., Ltd. ...	xi
I.P.O.E.E. Printed Papers	xv
Johnson & Phillips, Ltd.	xviii
London Electric Wire Co. & Smiths, Ltd.	ii
N.V. Electriciteits Maatschappy "Zeva"	xiv
Peel-Conner Telephone Works, Ltd.	xvii
Pitman & Sons, Ltd.	ii
Siemens Bros. & Co., Ltd.	vi and vii
Smith, Frederick, & Co.	xiv
Standard Telephones and Cables, Ltd.	x
Telephony Publishing Corp.	xii
The Electrical Review, Ltd.	iv and xii
The Relay Automatic Telephone Co, Ltd.	xvi
Tungstone Accumulator Co., Ltd.	xiii

THE ELECTRICAL REVIEW.

To the progressive Post Office Electrical Engineer the "REVIEW" offers the best means of keeping abreast with modern developments, not only in his own section of the industry, but also in every sphere in which electricity is employed both here and abroad.

Price 6d. weekly.

THE ELECTRICAL REVIEW, 4, Ludgate Hill, London, E.C.4.

The Engineering talent

all over the world reads TELEPHONY because it helps them keep abreast of the important developments in the telephone industry.

Telephony.
THE AMERICAN TELEPHONE JOURNAL

has been the leading journal in its field for 25 years—a quarter of a century of valued service to its readers. Subscription price (foreign, including postage) $5.00. Issued weekly.

TELEPHONY PUBLISHING CORP.,
608 S. Dearborn St., Chicago, Ill., U.S.A.

THE ONLY ACCUMULATOR IN THE WORLD WITH PLATE-GRIDS MADE OF PURE LEAD

with the Plate Grids Die Cast and Pasted entirely by machinery. Without Wood Separators or Celluloid, eliminating internal resistance and heat which shortens the life of other makes of plates, and creating constant trouble.

TUNGSTONE
Pure Lead Grid
Accumulator

ROBUST Machine-made Plates permit charge and Discharge at Continuous High Rates with Safety. No possibilities of the Plates Buckling or short-circuiting in service. No Fire or Explosion Risks when Charging above Normal Rates. A Tungstone Battery is not fully charged unless the Acid shows fully 1300 Sp.G. Tungstone Robust Machine Made Plates are in best condition when always kept fully charged.

VERY IMPORTANT ADVICE TO MOTORISTS.

Arrange for Car Dynamo output to be permanently increased so that at a car speed of 20 miles per hour the continuous charging rate is as follows, viz.:

40 a.h. Battery minimum charging rate is 8 amps.
50 a.h. „ „ „ „ 10 amps.
75 a.h. „ „ „ „ 15 amps.

Tungstone Machine Made and Pasted Plates are Heavier and Stronger than any other make of Plate, and therefore can be continuously charged at these higher rates than any other make of battery.

Tungstone Plate Grids being made of Pure Lead, and the Paste of Pure Lead Oxides, ensures exceptional storage capacity and quick discharges, therefore provision is made to give continuous, ample and generous power for Self-starting without cranking.
Follow these instructions and you permanently get the full benefits of the originality of Tungstone Design and Manufacture of a Pure Lead Plate and Grid giving exceptional Strength, Storage, Dependability, Reliability, Security, and Safety.

CHARGING HIGH TENSION AT 12-16 VOLTS POTENTIAL.

All H.T. Tungstone Accumulators are fitted with a Patent Equipment whereby each series of 12 Volts can be coupled in parallel so that these H.T. Batteries of whatever voltage can be charged at local Garages and Charging Stations on a 12-16 Volt Low Tension Charging Plant.
Charging Terminals are provided on the front of the Cabinet arranged in two rows, the top row being Positive and the bottom row Negative. When in use these charging terminals are connected in pairs so that all cells are in series.

☞ **Apply for copy, sent post free, Illustrated Booklet—**
"Photography tells the Story of the Tungstone Accumulator."

Please address all communications to the Distributors' Offices and Showrooms:
TUNGSTONE ACCUMULATOR CO., LTD.,
3, ST. BRIDE'S HOUSE, SALISBURY SQ., FLEET ST., LONDON, E.C.4
Telegrams: "Typify, Fleet, London." Telephone: Central 8157 (4 lines).

SOLD BY ALL DEALERS. T.24

Series of Patent Designs and Trade Mark Issued or Applied for in the Chief Countries of the World.

FREDERICK SMITH & CO.,

Incorporated in

The London Electric Wire Co. & Smiths, Ltd.,

ANACONDA WORKS, SALFORD, MANCHESTER.

HARD DRAWN H.C. COPPER LINE WIRE.

Special Tinned H.C. Copper Wire.

COPPER TAPES AND BINDERS FOR LINE WIRE.

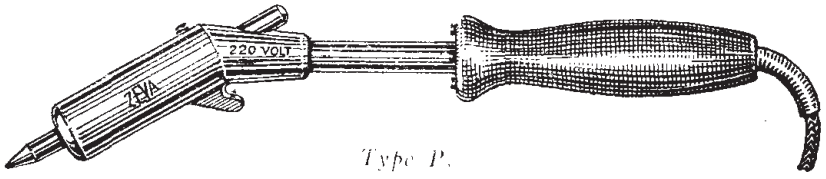
COPPER TROLLEY WIRE

SPECIAL NON-FOULING SECTIONS.

SILICIUM BRONZE WIRE

"C" Quality for Telephone Lines, &c.

Special Electric "Zeva,"
SOLDERING IRON
for Telegraph and Telephone purposes.



Type P.

Electric "Zeva" Soldering Irons have no need of spare-elements. As a consequence the costs of maintenance are nil.

N.V. ELECTRICITEITS MAATSCHAPPY "ZEVA,"
AMSTERDAM (HOLLAND).

Telegraphic Address: "ZEVA."

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

PRINTED PAPERS.

The following papers, contributed to the proceedings of the Institution, have been printed by authority of the Council and may be obtained from

"The LIBRARIAN,
The Institution of Post Office Electrical Engineers,
G.P.O. WEST, LONDON, E.C."

No. 54.† "THE LOADING OF AERIAL LINES AND THEIR ELECTRICAL CONSTANTS."—J. G. HILL ... ... 1s.
No. 57. "PRIVATE BRANCH EXCHANGES."—D. H. KENNEDY and J. W. TURNER ... ... 9d.
No. 59. "THE HISTORICAL BASIS OF MODERN PRINTING TELEGRAPHY."—H. H. HARRISON ... ... 9d.
No. 61. "WIRELESS CALL DEVICES."—L. B. TURNER ... ... 6d.
No. 64. "AN ADDRESS ON 'TELEPHONES.'"—SIR WILLIAM SLINGO ... 6d.
No. 65. "BUILDING MATERIALS: PROPERTIES, MANUFACTURE, AND USE OF."—L. TANNER... ... ... 6d.
No. 67. "MULTIPLE WAY DUCT WORK."—D. C. SAVORY ... ... 6d.
No. 70.† "TELEPHONOMETRY."—B. S. COHEN, A.M.I.E.E. ... ... 6d.
No. 72. "THE WESTERN ELECTRIC COMPANY'S AUTOMATIC TELEPHONE SYSTEM."—B. O. ANSON ... ... 1s.
No. 74. "THE ELECTRICAL PHYSICS OF THE ATMOSPHERE."—J. E. TAYLOR, M.I.E.E. 9d
No. 75.† "TELEPHONE REPEATERS."—A. B. HART ... ... 9d.
No. 79. "RECENT DEVELOPMENTS IN UNDERGROUND CONSTRUCTION."—A. O. GIBBON ... ... 9d.
No. 80. "SOME NOTES AND VIEWS UPON TELEPHONE FITTING WORK."—A. C. GREENING, A.M.I.E.E. ... ... 1s.
No. 81. "TELEGRAPH AND TELEPHONE ENGINEERING IN THE UNITED STATES."—SIR WILLIAM NOBLE, M.I.E.E. 1/6
No. 82. "SECONDARY CELLS."—R. G. DE WARDT, A.M.I.E.E. ... ... 1s.
No. 83.† "FOUR-WIRE TELEPHONIC REPEATER SYSTEMS." — C. ROBINSON, B.A., A.M.I.E.E., and R. M. CHAMNEY, B.Sc., Assoc.M.Inst.C.E. ... ... 9d.
No. 84. "THE RELAY SYSTEM OF AUTOMATIC SWITCHING."—H. W. DIPPLE, A.M.I.E.E. 1/3
No. 85.† "THE INFLUENCE OF TRAFFIC ON AUTOMATIC EXCHANGE DESIGN."—G. F. O'DELL, B.Sc., A.K.C., M.I.E.E. 1/6
No. 86. "SOME EXPERIMENTS ON CARRIER CURRENT TELEPHONY."—C. A. TAYLOR, B.Sc., and R. BRADFIELD, B.A., Assoc.M.Inst.C.E. ... ... 6d.
No. 87. "CONCRETE WORK AND REINFORCEMENT."—B. J. BEASLEY 6d.
No. 89.† "CORROSION OF LEAD COVERED CABLES BY ELECTROLYTIC ACTION."—S. C. BARTHOLOMEW, M.I.E.E. 1/3
No. 90.† "AUTOMATIC TELEPHONY IN MULTI-OFFICE AREAS."—G. F. O'DELL, B.Sc., A.K.C. ... ... 1s.
No. 91. "THE CENTRALISATION OF CORD REPAIRS." — G. F. BELLWOOD, A.M.I.E.E. ... ... 9d.
No. 92. "TELEPHONE METERS AND COIN COLLECTING BOXES."—W. CRUICKSHANK and F. MCCLARENCE ... ... 1s.
No. 97.† "THE ECONOMICAL PROVISION OF PLANT FOR TELEPHONE DEVELOPMENT." — G. H. A. WILDGOOSE, A.M.I.E.E., and A. J. PRATT, A.M.I.E.E. ... ... 9d.
No. 98. "MAINTENANCE PRECISION TESTING OF MAIN TRUNK CABLES."—B. LISTER ... ... 1s.
No. 99.† "RECENT RESEARCH WORK ON TELEPHONE REPEATERS." C. ROBINSON, B.A., A.M.I.E.E., and R. M. CHAMNEY, B.Sc., Assoc.M.I.C.E. 1/3
No. 100.† "SIEMENS No. 16 AUTOMATIC EQUIPMENT."—CHAS. W. BROWN, A.M.I.E.E. 1/3
No. 101.† "TELEPHONE TRANSMISSION."—J. E. STATTERS 1/3

† The Council have awarded Institution Medals for these papers.

RELAY

AUTOMATIC TELEPHONES

QUETTA PUBLIC EXCHANGE BUILDING

India's Tribute

THE following letter has been received from the Office of the Deputy Postmaster-General, Sind Baluchistan :—

"I am completely satisfied with the Quetta Exchange. It has given no trouble whatever, and the opinions of the Subscribers whom I have asked about the service are unanimously favourable. I congratulate you on the successful installation of an excellent system."

The "Relay" system is unique—it employs no electro-mechanical switches, but is constructed entirely with relays of special design and manufacture. It is practically silent and motionless, and is immune from troubles due to dust, heat, vibration, etc. There is no wear and tear, and maintenance is reduced to a minimum.

"Relay" installations have been supplied to 18 Governments and administrations and more than 150 installations have been supplied to the British Post Office.

Write for fully illustrated technical booklet No. 9.

THE RELAY AUTOMATIC TELEPHONE CO., LTD.,

Marconi House, Strand, London, W.C.2.

Branches:—Birmingham, Cardiff, Glasgow, Manchester. *Representatives all over the world.*

PEEL-CONNER
"LONG-LIFE" CORDS

The economics of the telephone cord, whether for the subscriber's set or the switchboard, provide a useful field for study by the telephone maintenance engineer.

There is much more in the subject than at first sight appears. When tendered prices are under consideration prior to an order being placed a leaning towards the lowest price must very generally be felt. There comes into play, however, the maintenance cost, often considerable, of sending a mechanic to replace or repair a worn-out cord, and also the great damage to the reputation of the service resulting from the trials of the subscriber in the period during which the cord by "scraping" and "cut offs" is fitfully announcing its approaching end.

The greater the useful life of the cord the less frequent these two burdens become, and the resulting reduction in the annual maintenance costs and the improved relations with the telephone using public will many times outweigh the slightly greater first cost of the "Long-Life" cord.

For over four years the Peel-Conner "Long-Life" cords have been used by many telephone administrations all over the world. Even in tropical countries there are administrations that, having tested and proved the merits of our "Long-Life" cords, have settled on their use as the standard for the future.

Quotations and full details of Peel-Conner "Long-Life" Cords and Cordage will gladly be furnished upon application being made to either of the addresses below.

PEEL-CONNER TELEPHONE WORKS

(Proprietors—The General Electric Co., Ltd.)

COVENTRY, ENGLAND.

HEAD OFFICE AND WORKS:
STOKE, COVENTRY.
Telephone: COVENTRY 1310.
Telegrams:
"SPRINGJACK," COVENTRY.

LONDON OFFICE:
MAGNET HOUSE,
KINGSWAY, W.C.2.
Telephone: REGENT 7050.
Telegrams:
"Peelcontel, Westcent, London."

Half a century's experience

is built into every yard of Trunk Telephone Cable manufactured and suppied by us.

That such experience and the articles produced creates confidence among buyers is proved by our constantly increasing business in this direction.

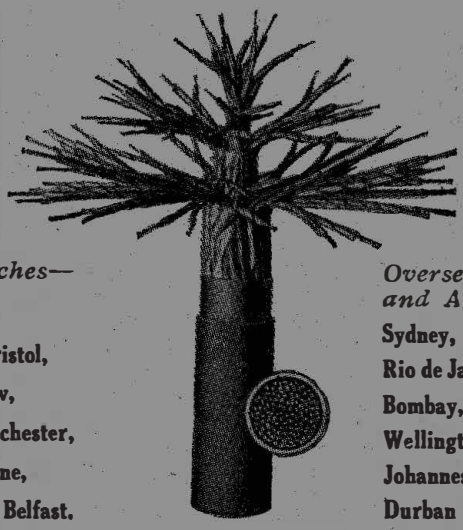
The efficiency of the National Telephone service depends largely on J. & P. Cables because they are used in constantly increasing quantities, and that they are so used should influence larger and more frequent orders from the Dominion and other authorities.

It should influence *you* to a favourable consideration of the Cable distinguished by that "little more" in quality which means so much in service.

JOHNSON & PHILLIPS, Ltd.

Where the Cables come from.

Charlton, London, S.E.7.

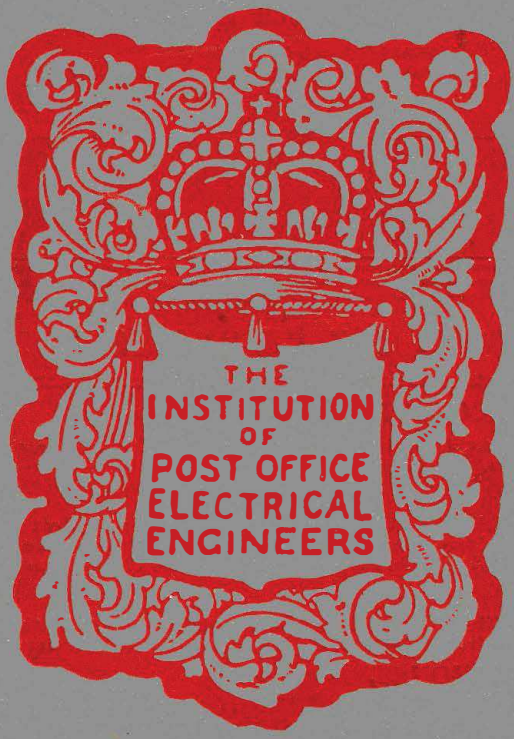


Home Branches—
London (City), Birmingham, Bristol, Cardiff, Glasgow, Liverpool, Manchester, Newcastle-on-Tyne, Portsmouth & Belfast.

Overseas Branches and Agencies at—
Sydney, Melbourne, Rio de Janeiro, Calcutta, Bombay, Madrid, Wellington (N.Z.), Johannesburg, Durban and Singapore.

Printed by Birch & Whittington, Epsom, and
Published by The Electrical Review, Limited, at 4, Ludgate Hill, London, E.C.

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL



VOL. 19 PART 3

OCT: 1926

Price 1/6 net.

ADVERTISEMENT INDEX
see page xii.

The

LONDON ELECTRIC WIRE COMPANY & SMITHS, Ltd.

Manufacturers of

Every Description of Cables and - Wires for Electrical Purposes -

Cotton-Covered and Braided Wires. Cotton-Covered Strips and Cables. Silk-Covered and Enamel Insulated Wires. Multiple Cables. Flexible Cords. Cables and Flexibles for Wireless Work.

"Eureka," Nickelchrome and other High Resistance Wires.

Playhouse Yard, Golden Lane, London, E.C.1.

Telegrams: "*Electric, London.*"
Telephone: *Clerkenwell* 1388, 1389, 1390, 1391.

Pitman's Books for Engineers and Students.

ELEMENTARY TELEGRAPHY.

By H. W. PENDRY. Second Edition. Specially written for candidates for C. & G. I. Examinations. 189 Illustrations. **7s. 6d.** net.

TELEGRAPHY.

By T. E. HERBERT, M.I.E.E., Assistant Superintending Engineer, Post Office Engineering Dept. A Detailed Exposition of the Telegraph System af the British Post Office. Fourth Edition. Revised and Enlarged. 1040 pages. 640 Illustrations. **18s.** net.

TELEPHONY.

By the same Author. This work contains full information regarding the Telephone Systems and Apparatus used by the British Post Office. 883 pages. 618 Illustrations. **18s.** net.

AUTOMATIC TELEPHONES.

By F. A. ELLSON, B.Sc. Hons. (Vict.), A.M.I.E.E., *Engineer, G.P.O.* An introductory treatise dealing with the fundamental principles, methods, and advantages of automatic telephony. 227 pages. 48 Illustrations. **5s.** net.

THE PRACTICAL TELEPHONE HANDBOOK AND GUIDE TO THE TELEPHONE EXCHANGE.

By JOSEPH POOLE, A.M.I.E.E., Wh.Sc. This book is recommended by the Examiners for the City and Guilds Institute Examinations in Telephony. Seventh Edition, thoroughly revised. 725 pages. 585 Illustrations. **15s.** net. (Ready shortly)

ARITHMETIC OF TELEGRAPHY AND TELEPHONY.

By T. E. HERBERT, M.I.E.E., and R. G. DE WARDT, *of the Post Office Engineering Department.* Suitable for candidates for City and Guilds Institute Grade I. Examination. 187 pages, 37 diagrams. **5s.** net.

RADIO COMMUNICATION, MODERN.

By J. H. REYNER, B.Sc. (Hons.), A.C.G.I., D.I.C., *of the Post Office Engineering Dept.* A manual of modern theory and practice, covering the syllabus of the City and Guilds Examination and suitable for candidates for the P.M.G. certificate. Second Edition, thoroughly revised. 220 pages. 121 Illustrations **5s.** net.

THE BAUDOT PRINTING TELEGRAPH SYSTEM.

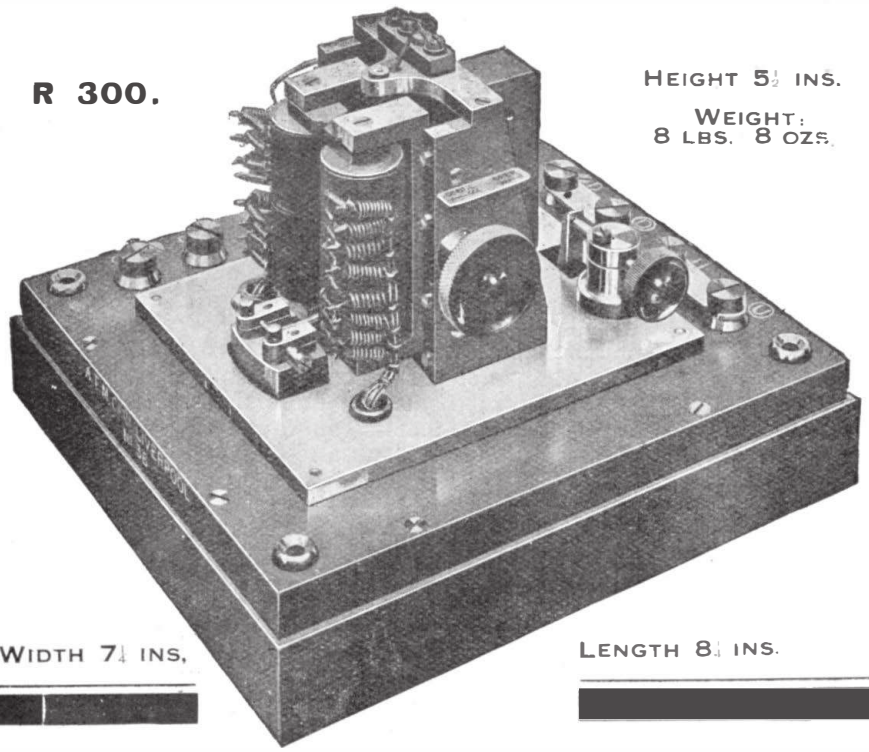
By H. W. PENDRY. Second Edition. With 72 illustrations of the latest models. **6s.** net.

Complete list post free: **PITMAN'S, Parker Street, Kingsway, W.C.2.**

R 300.

HEIGHT 5½ INS.

WEIGHT:
8 LBS. 8 OZS.



WIDTH 7¼ INS.

LENGTH 8¼ INS.

A.T.M.

GULSTAD RELAY

CABLE PATTERN

THIS pattern relay has been developed for specially difficult lines and submarine cables.

The adjustment of the contact carriage and the relation of the electromagnet cores to the armature system is of wide range and can be made in minute steps.

The frame in which the coils slide is very rigid and the relay is not susceptible to extraneous vibations.

SEND TO-DAY
FOR
CATALOGUE
No. 39.

AUTOMATIC TELEPHONE
MANUFACTURING CO., LTD.

Head Office and Works:

MILTON ROAD,
EDGE LANE,
LIVERPOOL.

London Office:

NORFOLK HOUSE,
NORFOLK STREET,
STRAND, W.C.2

The Post Office Electrical Engineers' Journal.

A QUARTERLY JOURNAL.

CONTENTS FOR OCTOBER, 1926.

COPYRIGHT.—The entire contents of this Journal are covered by general copyright, and special permission is necessary for reprinting long extracts, but Editors are welcome to use not more than one third of any article, provided credit is given at the beginning or end thus: "From the 'Post Office Electrical Engineers' Journal.'"

	PAGE
THE PENOT MORSE PRINTER—A. C. Booth	235
A HIGH QUALITY TELEPHONE TRANSMISSION SYSTEM—B. S. Cohen, M.I.E.E.	237
JUBILEE OF THE TELEPHONE	249
TIME SAVING TESTERS. FOR AUTOMATIC EXCHANGES—W. Prickett and H. S. Smith	252
REMARKABLE VITALITY OF A P.A.B.X. EQUIPMENT	257
THE TUNGAR RECTIFIERS—H. C. Jones, B.Sc.	260
TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM	270
THE ANGLO-DUTCH No. 3 CONTINUOUSLY LOADED SUBMARINE TELEPHONE CABLE—A. B. Morice, B.Sc. (Eng.), A.M.I.E.E.	271
NOTES AND COMMENTS	284
HEADQUARTERS NOTES	288
LONDON DISTRICT NOTES	290
FEDERATED MALAY STATES. ANNUAL REPORT, 1925. POSTS AND TELEGRAPHS	292
LOCAL CENTRE NOTES	295
BOOK REVIEWS	298
STAFF CHANGES	300
THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS. PROGRAMME, 1926-27	303
MEMBERS OF COUNCIL AND OFFICERS FOR THE YEAR 1926-7	306
ESSAY COMPETITION, 1926-27	307
COMMUNICATIONS	308

All communications with regard to advertisements to be addressed to:

The Advertisement Manager,
Post Office Electrical Engineers' Journal,
4, Ludgate Hill, London, E.C.4.

PUBLISHERS:

THE ELECTRICAL REVIEW, LTD., 4, LUDGATE HILL, E.C.

Price 1/6 net, post free, 1/9. | **Annual Subscription, postage inclusive, 7/-, payable in advance.**

— and then he got a trouble-free 'phone system!

THE exasperating breakdowns, delays and muffled speech encountered on ordinary phone systems fade away when an Ericsson System is installed.

Trouble-free, clear-speaking and carrying a tiny maintenance bill, it proves a wonderful business aid and soon repays its moderate initial cost. Stands up wonderfully well to hard wear.

Write to-day for free fully illustrated and informative pamphlets.

ERICSSON TELEPHONES LIMITED
International Buildings,
67-73, Kingsway,
London, Eng., W.C.2.

WORKS: BEESTON, NOTTS

Telephone: Gerrard 3003, 3004

Telegrams: Ericsson, Westcent, London.

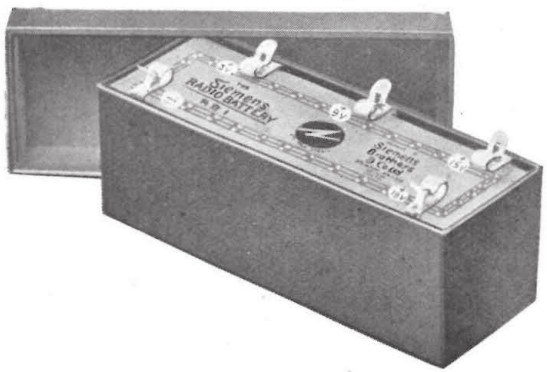
Ericsson

TELEPHONE EXCHANGE EQUIPMENT.

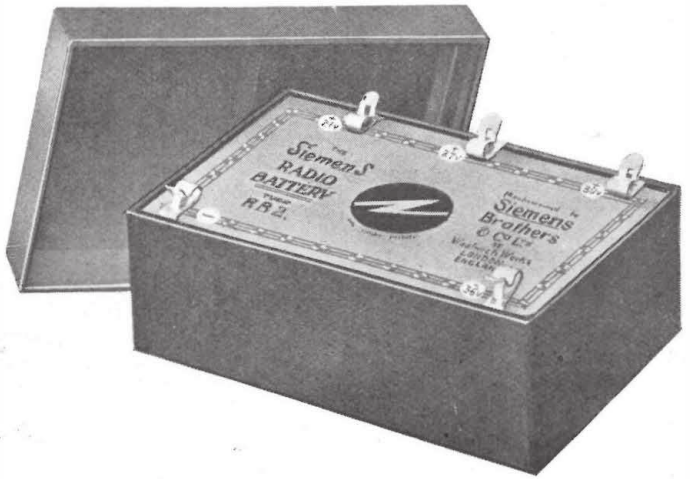
SIEMENS

H.T. DRY BATTERIES.

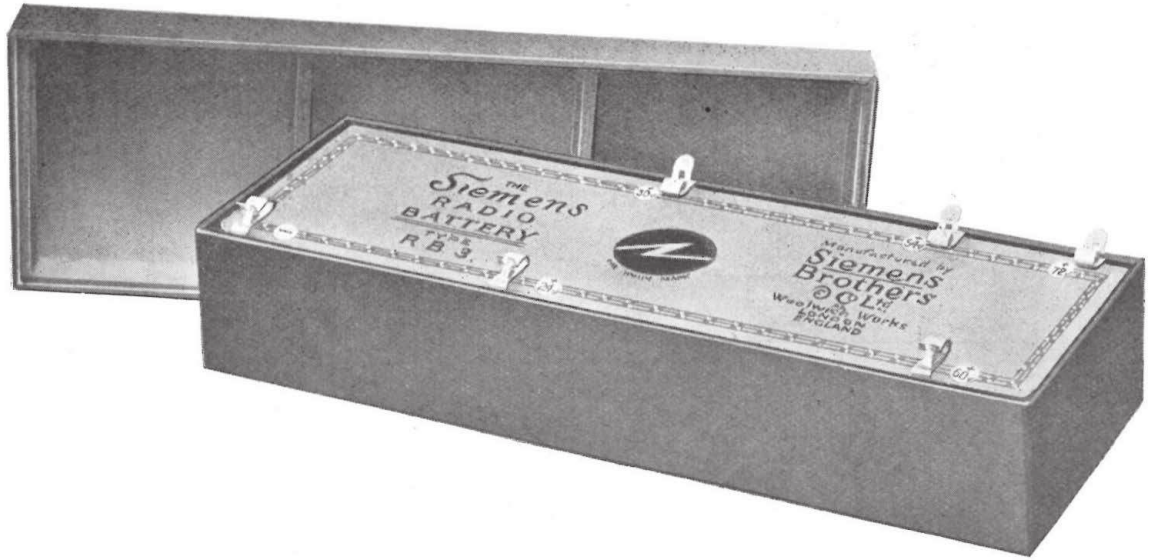
NEW TYPE—LARGE CAPACITY.



Type R.B. 1., 18 Volts.



Type R.B. 2., 36 Volts.



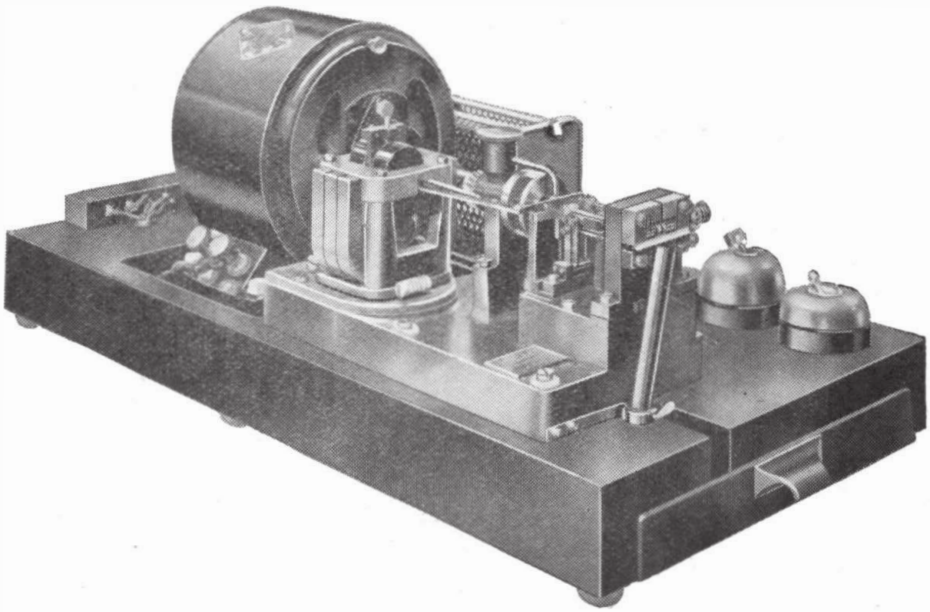
Type R.B.3., 72 Volts.

THESE H.T. DRY BATTERIES EMBODY ALL THE IMPROVEMENTS WHICH OUR EXPERIENCE OF THE REQUIREMENTS OF MODERN BBOADCAST RECEPTION HAS SHOWN TO BE NECESSARY.

Descriptive Price Sheet 645 will be sent on application.

SIEMENS BROTHERS & CO., LIMITED, WOOLWICH, LONDON, S.E. 18.

CREED INSTRUMENTS



THE CREED RECEIVER

The Creed 1924 design Receiving Perforator is the acme of simplicity. With the instrument, motor, sliding resistance and switches mounted on a strong and light aluminium base, it forms a compact and serviceable unit. Speed ranges from 30-60 to 75-150 words per minute (with high speed motors, up to 200 w.p.m.), or a 3-speed change gear attachment can be fitted with a normal range from 20 to 180 w.p.m.

We are now manufacturing

START—STOP APPARATUS

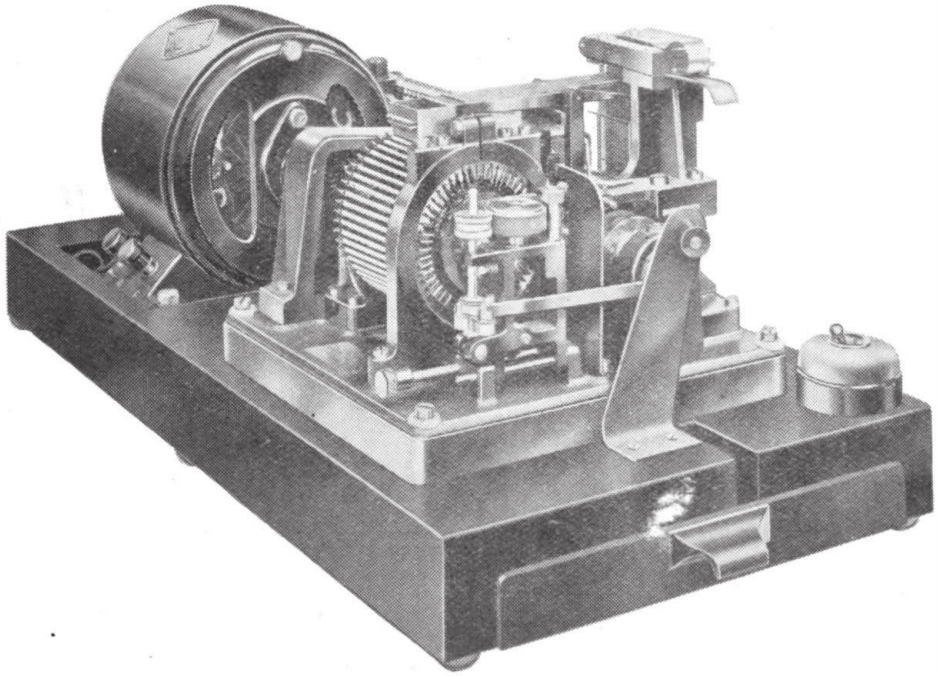
Write to us for particulars

CREED & CO., LTD.,

Telegraph Engineers,

Telephone : Croydon 2121.

CREED INSTRUMENTS



THE CREED PRINTER

The Creed 1924 design Printer, like the Receiver, is now mounted on a light aluminium base with the motor and sliding resistance forming a similar compact unit. Speed 150 words per minute. Tape wheel drawers are fitted in the base of both instruments.

MURRAY MULTIPLEX

We also manufacture apparatus for this System.

Write to us for particulars.

TELEGRAPH WORKS
CROYDON, SURREY

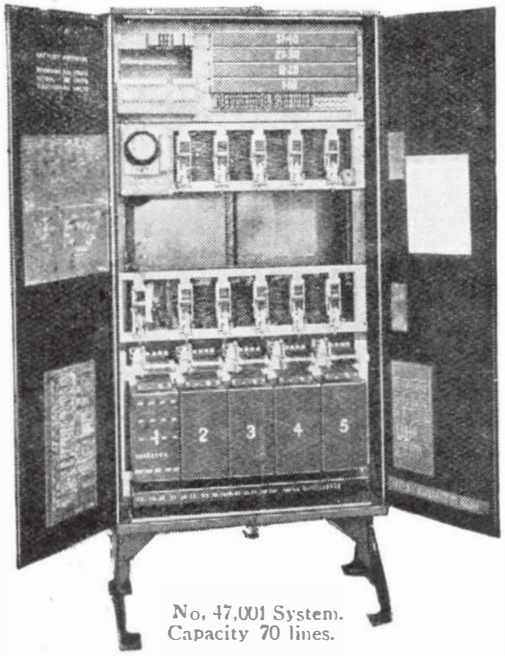
Telegrams : "Credo, Croydon."

Standard

FORMERLY

Western Electric

Automatic Telephone Systems



No. 47,001 System.
Capacity 70 lines.

STANDARD Automatic Private Branch Exchanges are essential to all business houses. They represent a time-saving factor of great value and increase the general efficiency of any organisation.

Here are some points for consideration :—

1. No operator is required, therefore the annual cost is negligible compared with a manually-operated switchboard.
2. The apparatus is ready for use day and night—or 8,760 hours per annum.
3. Absolute secrecy is secured on every call without any special manipulation of the Set on the part of the user.
4. High speed of operation. There is no waiting on the No. 47001 system, as the number is selected by the mechanism during the process of dialling.
5. The caller is instantly advised if the wanted line is engaged and (should he decide to hold the telephone for a minute or so) he is automatically connected as soon as the required line is free.
6. The caller is given confidence in the apparatus as he supervises the call and can hear the distant bell ringing.
7. The apparatus is simple to instal, being in standardised unit form.
8. It is economical to house because it may be fitted in a position which would be unsuitable for an operator.

Standard Telephones and Cables Limited

Connaught House, Aldwych, London, W.C.2.

'Phones: CENTRAL 7345 (10 lines). Works: HENDON, NORTH WOOLWICH and NEW SOUTHGATE. Branches: Glasgow, Leeds, Birmingham, Manchester, Cardiff, Liverpool, and Dublin.

THE
Post Office Electrical Engineers' Journal

THE PÉNOT MORSE PRINTER.

By A. C. Booth.

In "Annales des Postes, Télégraphes et Téléphones" for May, 1926, a very full description is given of an automatic printer for converting ordinary Morse signals of dots and dashes into Roman printed characters without the intervention of a perforated tape as is used in the well-known Creed system. The printing can be done on the ordinary tape or in column form. The description is too long to be reproduced in full in this Journal, but a brief outline of the scheme and the essentials are given in the following notes to enable an opinion to be formed of the device. It is a French production by M. Pénot and is patented in that country. It is said to have been used with complete success by the French Administration for printing the reception of Morse signals received from various International Radio services. It can be used also on submarine cable services as well as on land lines. The speed at which it can be worked is not given, beyond the statement that it will print at the highest speed used on busy Radio services. That may mean hand-signalling speed or even automatic transmission up to about 60 words a minute. It is probably not sufficiently rapid in action to deal with a speed much over 100 words a minute, judging by the detailed description of the apparatus supplied in the article referred to.

In addition to the ordinary telegraphic receiving apparatus there are three special other instruments to effect the translation of the Morse characters into printed Roman characters, viz., the Regulator, which is adjusted to the speed of the sending station; the Distributor, which selects the dots and dashes; and, lastly, the

Printer, which is controlled by the Distributor and prints the required character corresponding to the Morse signals received.

The Regulator has a main axle driven by a motor through a friction clutch. Normally the axle is held stationary by an escapement, or, as it is termed, an anchor, which is moved to and fro by the arriving signals. The axle has a small pulley which acts on one or other of two discs, thus winding up one or other of two flat spiral springs by an amount determined by the duration of the signals. One disc is for the marking signals, whether dots or dashes, and the other for the spacing signals of whatever length.

The two axles upon which the discs are mounted are fitted with commutators to make connection with different parts of the Distributor. These connections are determined by the extent of the angle through which the commutators have been moved, and consequently are made in accordance with the duration of the arriving signal, which may be a dot and dash on the marking side, or a letter-space or a word-space on the spacing side.

The Distributor has a number of pairs of pivoted axes, each fitted with a number of flat spring contacts which make or break connection with a corresponding number of fixed contacts according to whether the axes are in one or other of two positions. These positions are determined by electro-magnets controlled by currents from the Regulator. Each pair of axes functions independently, one with dots, the other with dashes. Hence for the letter P, for example, four pairs of axes will be required, so that the total number of pairs of axes is that of the Morse signal having the largest number of dots or dashes. The letter-space signal determines the printing. There is another axis which prevents printing when incorrectly formed or distorted signals are received.

The Printer is of the type-wheel form, driven by a friction clutch from an electric motor. The type-wheel is stopped when required by projecting pins actuated electrically by the Distributor. A printing magnet presses the tape against the type-wheel at the selected character, and also feeds forward the paper tape. The printer may also be of the drum type to print in page-form if required.

Further details regarding the results obtained with this apparatus would be interesting particularly with reference to the speed obtained and its reliability when working near to its maximum.

A HIGH QUALITY TELEPHONE TRANSMISSION SYSTEM.

By B. S. Cohen, M.I.E.E.

In the last issue of the Journal, under a note on " A Reference Telephone Transmission System," mention is made of a high quality system developed by the British Post Office. This was not put forward for use as a basic reference standard inasmuch as no data regarding its stability was available. The frequency characteristics of its component parts are sufficiently flat, however, to result in an overall articulation from mouth to ear which is practically perfection, *i.e.*, of the order of 100% efficiency. It is thought that a description of this system, which was to a considerable extent designed and built at the Research Station, Dollis Hill, would prove of interest, particularly as a detailed description will involve the elucidation of some of the acousto-electric problems of telephone transmission which have received so much attention during the past few years.

The complete system consists of a transmitter, a transmitter amplifier and coupler, an artificial line, a receiver amplifier and coupler and a receiver.

Transmitter.

The transmitter adopted is an electromagnetic device. It is the invention of C. W. Hewlett and may be referred to as an eddy current instrument. It consists of a lightly stretched diaphragm of thin aluminium foil, placed between two concentrically wound flat coils of wire, which are connected in series and in magnetic opposition so that a current through these coils will produce a radial magnetic flux between them. The coils are wound with annular air spaces in order to enable sounds to pass in and out to

the foil diaphragm. This instrument can be used either as a transmitter or a receiver. When used as a transmitter, sound falling on the aluminium diaphragm moves it backwards and forwards in the field caused by the direct current flowing in the flat coils, and this motion sets up eddy currents in the diaphragm which in their turn produce a fluctuating magnetic field superimposed on the stationary field, and by the use of a suitable transformer the corresponding voltage changes can be utilized.

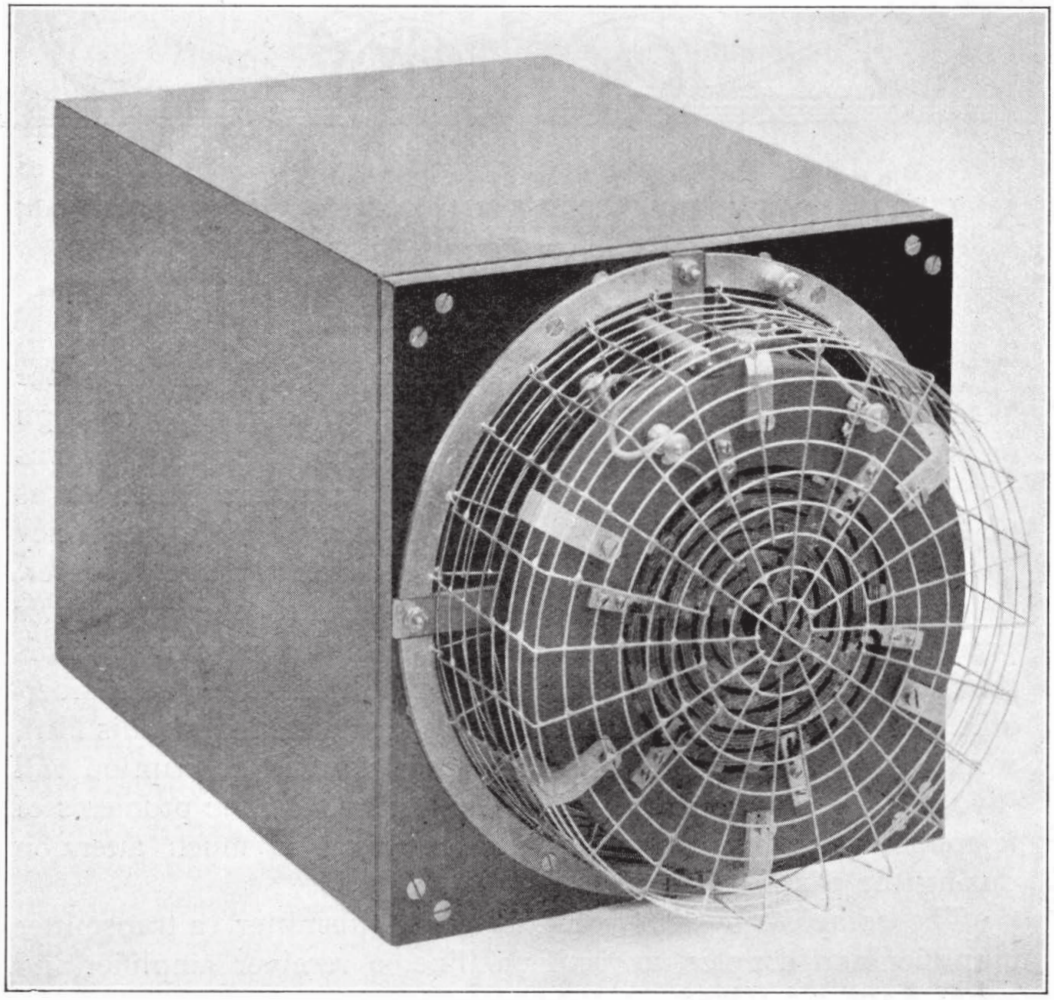


FIG. 1.—THE TRANSMITTER.

There is no iron present and the acousto-electric transformation is remarkably pure. Fig. 1 shows the complete instrument. The back is enclosed by the wooden box which is filled loosely with cotton waste. This prevents interference effects between sound waves impinging on the front and the back of the diaphragm; this effect is particularly liable to happen at the lower audio frequencies. At the same time the loose cotton waste absorbs the sound waves

produced by the motion of the diaphragm without the production of reflection.

The whole transmitter is also enclosed in a wire cage connected to earth; the front of this is visible in the photograph. This cage acts as a shield to prevent electrostatic induction. The polarizing current required is of the order of 0.7 ampere. This form of transmitter is insensitive, having only about 1/5000th the sensitivity of an ordinary commercial C.B. transmitter and in consequence requires an amplifier giving that order of amplification to render it equivalent to an ordinary transmitter. A four stage resistance capacity coupled audio frequency amplifier is used for this purpose; Fig. **2** shows the connections of the transmitter and its

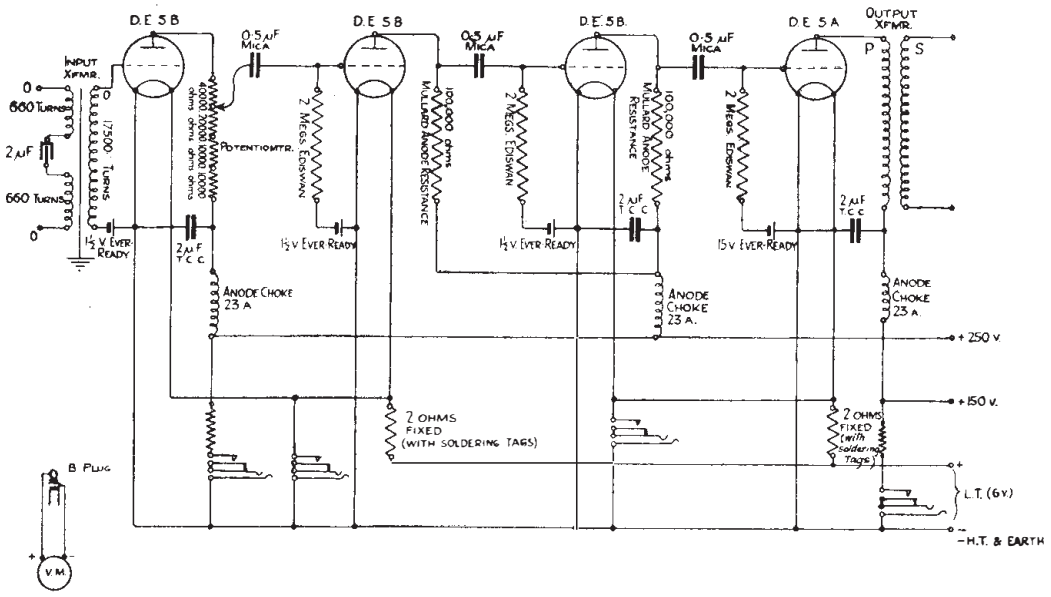


FIG. 2.—TRANSMITTER 4-STAGE AMPLIFIER.

associated amplifier. The three first stages are D.E. 5B valves, which have very high amplification and impedance, and the last stage is a D.E. 5A, which is of much lower impedance and may be described as a small power valve.

A potentiometer is connected in the anode circuit of the first stage and controls the magnification in 4 steps, giving full, $\frac{1}{2}$, $\frac{1}{4}$ or $\frac{1}{8}$ magnification.

Three separate anode chokes are used to connect up the H.T. battery and these connections are also shunted by 2 μF condensers. The filament supply is controlled by fixed resistances. By these means the amplifier, although giving a considerable amplification, is silent and free from self-oscillation. The amplifier is enclosed as a whole in a metal screen.

The efficient coupling of the eddy current transmitter to the amplifier requires a specially designed transformer, and particulars

of this will be of interest. The A.C. resistance of the eddy current transmitter is 10 ohms and its impedance over the audio frequency range is of the order of 90 /80° ohms.

The input transformer is built on a stalloy stamping core of $\frac{3}{4}''$ square section and consists of interleaved primary and secondary windings. There are 4 primary windings each of 330 turns, total 1,320 turns, and 5 secondary, 3 of which are each of 4,500 and the

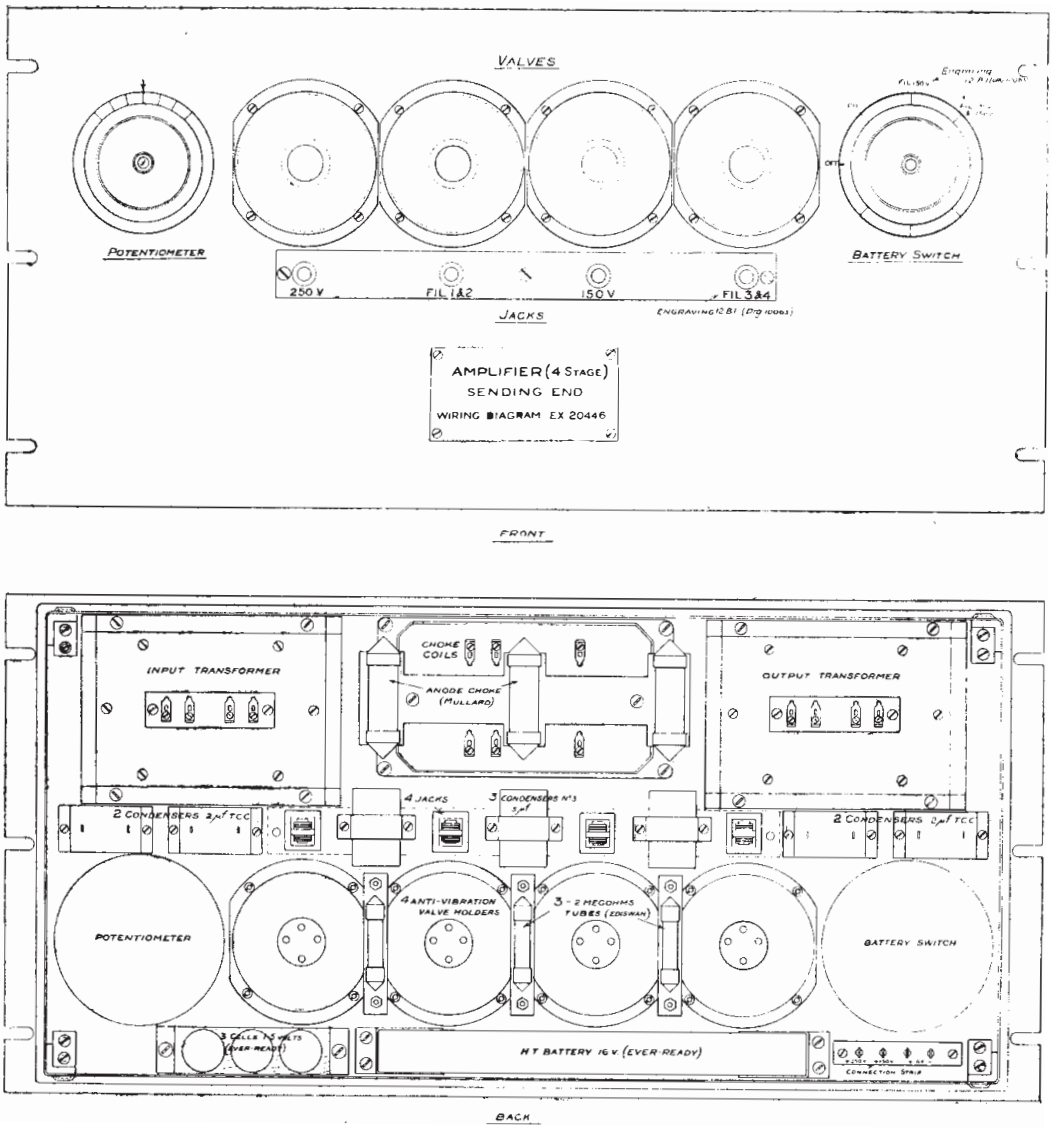


FIG. 3.—TRANSMITTER AMPLIFIER ASSEMBLY.

remaining two of 2,000 turns, so that in all there are 17,500 turns in the secondary, *i.e.*, a step up of about 15 : 1. The primary winding is divided in halves and connected to the eddy current transmitter in the manner shown. The output transformer for the transmitting amplifier has to step down from the anode impedance of the D.E. 5A valve (about 2000 ohms), to a 600 ohms non-

reactive line. This is also an interleaved winding transformer, giving a step down of about 2 : 1. The jacks shown in the circuit are for the purpose of plugging in a voltmeter for measuring filament, grid and anode voltages.

This amplifier is built up on a metal back plate provided with a metal cover and mounted on a small rack. Fig. **3** shows back and front views of this assembly.

Calibration of the Transmitter.

The detailed explanation of the calibration of the transmitter would be a lengthy one and outside the scope of the present article. It will, however, be advisable to give a short and general explanation of the methods adopted, as these are typical of the more scientific methods of quantitively measuring transmission apparatus which it is anticipated will ultimately replace the much less accurate older methods. The behaviour of a telephone transmitter, *i.e.*, an acousto-electric transformer, may be quantitively measured as regards its volume and articulation qualities by measuring the ratio of the acoustic input pressure (in dynes per sq. cm.) to its output volts for all frequencies in the audio range. The range of audio frequency that is of any importance in the reproduction of high quality speech may be taken as of the order of 100—5000 p.p.s., whilst a range of from 30—10,000 p.p.s. may be assumed to be ideally perfect for the reproduction of music and noises.

Apparatus is now available which produces pure sounds over most of this range, and sinusoidal A.C. over the whole of the range. Apparatus also exists which is capable of measuring the acoustic and electric pressures respectively of these supplies. With these four essentials it is possible to measure the acousto-electric ratios of transmitters, the electro-acoustic ratios of receivers and the electric-input—electric-output ratios of lines and circuits. Description of this apparatus must be deferred to another time. Reference may, however, be given to the paper entitled "The Frequency Characteristics of Telephone Systems and Audio Frequency Apparatus and their Measurement": B. S. Cohen, A. J. Aldridge and W. West: Journal I.E.E., No. 358, 1926, in which details of this apparatus will be found.

Let us assume then that we have apparatus available to produce a known acoustic input pressure p over the audio range on a transmitter diaphragm and to measure the corresponding voltage output E. The greater the ratio E/p at any given frequency, the greater will be the volume efficiency at that frequency. By plotting E/p against frequency, a frequency characteristic is obtained which will be a measure of the articulation efficiency.

Defining articulation as perfection of reproduction of originat-

ing wave form, a frequency characteristic consisting of a straight line parallel to the frequency axis would indicate that E/p would be a constant at all frequencies and in consequence that the apparatus would reproduce perfectly.

A sudden increase in E/p at any frequency or band of frequencies indicates resonant conditions at those frequencies. In the same way if E/p at the lower or higher frequencies was very small, or zero, it would indicate that the apparatus was incapable of responding to the lower or higher audio frequencies respectively.

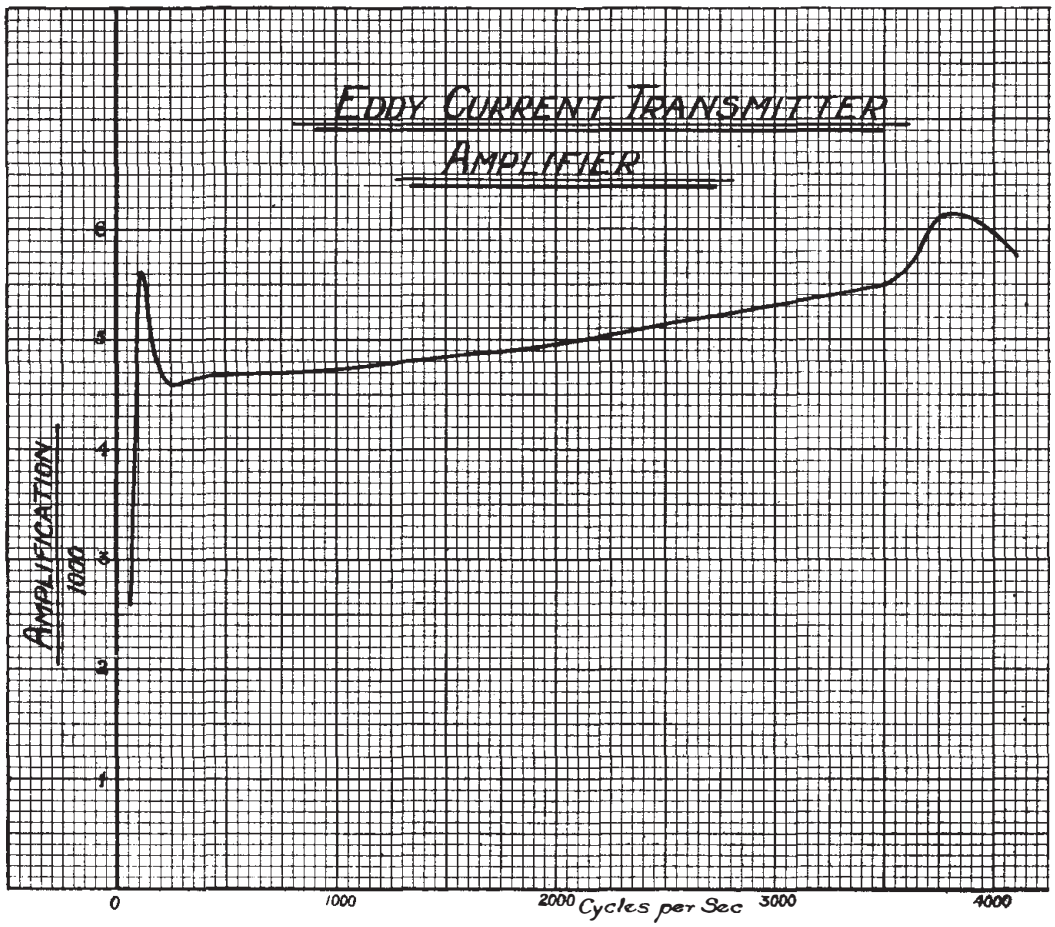


FIG. 4.—FREQUENCY CHARACTERISTIC OF TRANSMITTER AMPLIFIER.

Owing to the accommodating qualities of the ear, however, apparatus with frequency characteristics departing to some extent from the ideal will yet give very high quality articulation.

We are now in a position to consider the frequency characteristics of the eddy current transmitter and its associated amplifier.

Fig. 4 is the frequency characteristic of the 4 stage amplifier used with the eddy current transmitter. In this case the Amplification/1000 is plotted against frequency. It will be observed that the amplifier resonates at about 100 p.p.s. This is due to

resonance in the input transformer, which has a 2 μF. condenser connected in its primary for this purpose. This resonance helps to push up the efficiency of the transmitter at the lower end. Beyond this the amplification remains substantially constant.

Fig. 5 shows the acousto-electric frequency characteristic of the eddy current transmitter and the ratio plotted against frequency is microvolts/dynes per sq. cm. The efficiency rises gradually to a maximum and then falls at the higher frequencies to the order of the values at the lower end of the audio range. The maximum variation, however, is about 30 : 10. There is a physiological law

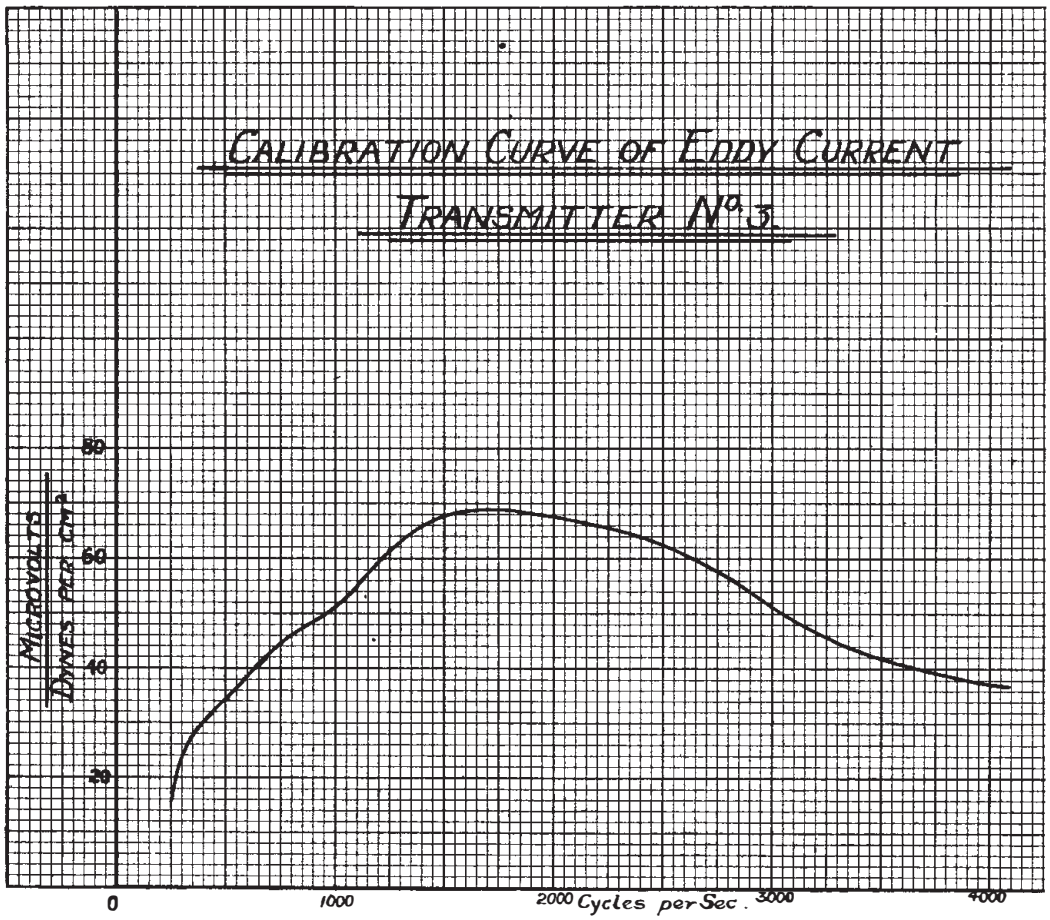


FIG. 5.—ACOUSTO-ELECTRIC FREQUENCY CHARACTERISTIC OF TRANSMITTER.

termed Fechner's law to the effect that sensation is proportional to the logarithm of the stimulus. This law applies to acoustic as well as to other sensations.

In the case of the characteristic for the eddy current transmitter, the comparative sensations produced on the ear by sounds varying in loudness by 10 : 30 would be of the order therefore of only 1 : 1.5. It should be noted that the variations in the ratio E/p for commercial types of transmitters and receivers in general use over the audio range is enormously greater.

The combined eddy current transmitter and amplifier characteristic is plotted in Fig. **6**. It will be observed that the amplifier to some extent corrects the transmitter characteristic. For purposes of comparison a typical characteristic for a C.B. solid back transmitter is also shown in dotted lines.

The artificial line.

This consists of a non-reactive line with a range of from 0.01*b* to 11*b* by steps of 0.01*b* (approximately 0.09 to 96 T.U.). The impedance of this line is 600 /0 ohms and it is built up of T section

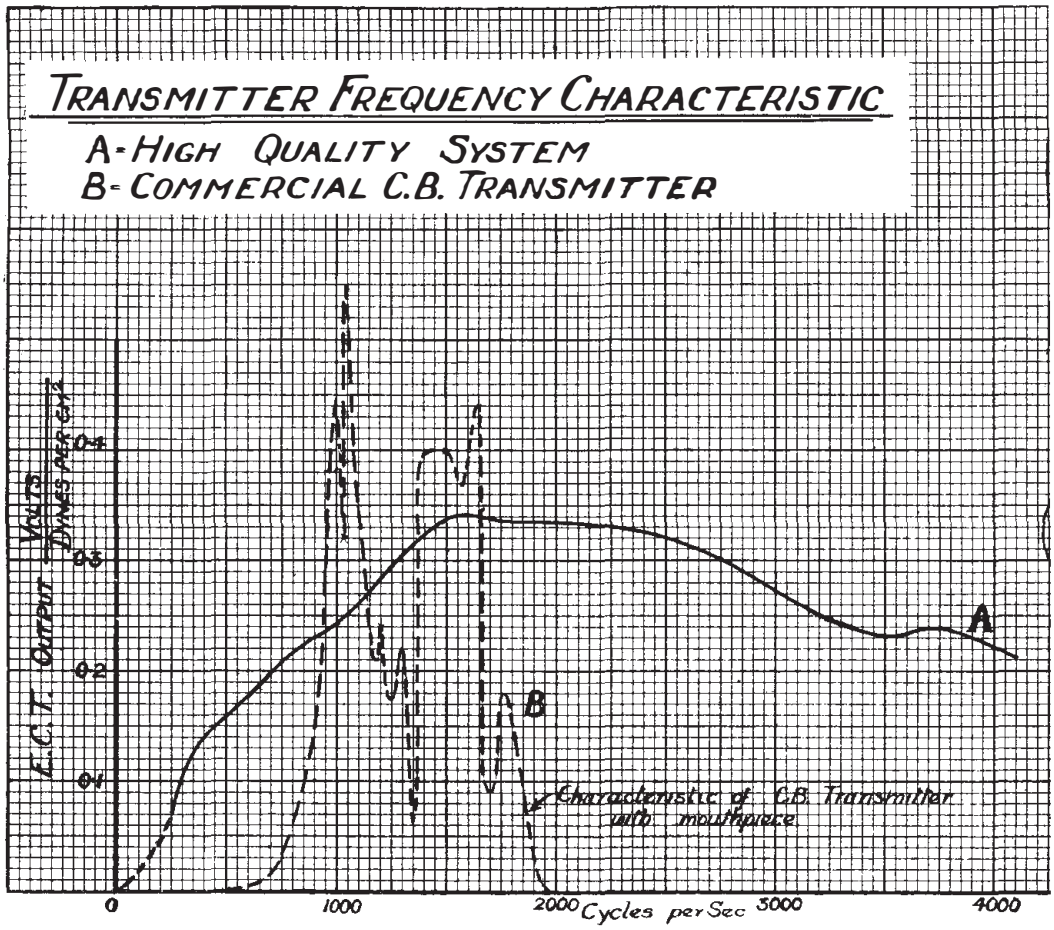


FIG. 6.—COMBINED TRANSMITTER AND AMPLIFIER CHARACTERISTIC.

non-inductive resistances. This line is adjusted by three dials giving ranges of 0.01 – 0.1, 0.1 – 1 and 1 – 10*b* respectively. (Note $b = \beta l$.)

This line is mounted on a separate small rack together with voltmeter for measuring filament, anode and grid voltages.

The Receiver.

The receiver is of a special moving coil electro-magnetic type designed and built at Dollis Hill.

Fig. **7** shows the general assembly of the instrument, and Fig. **8** is a photograph of the disassembled instrument. The instrument has an electro-magnet with concentric pole-pieces, giving an annular field in which a very light moving coil can operate. This moving coil consists of 300 turns of No. 47 S.W.G.

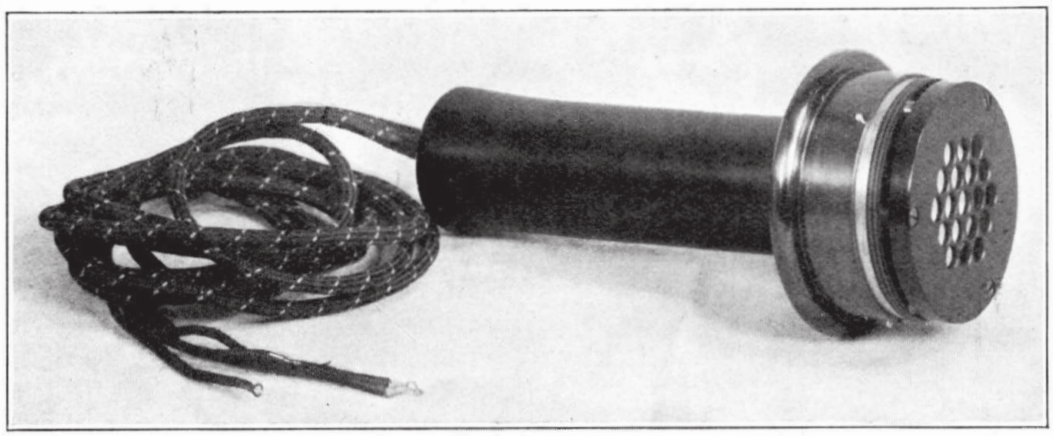


FIG. **7**.—RECEIVER ASSEMBLY.

copper wire, 500 ohms in resistance. The coil and its former only weigh $\frac{3}{4}$ gramme. The former is provided with feet by which it is fastened to a disc of elder pith, 1 inch in diameter and 3/16 inch thick and weighing about $\frac{1}{4}$ gramme, and also to a diaphragm of oiled silk, 2 inches in diameter, clamped around its circumference and only slightly stretched. The feet of the former provide an air gap round its base and prevent the trapping of air inside the

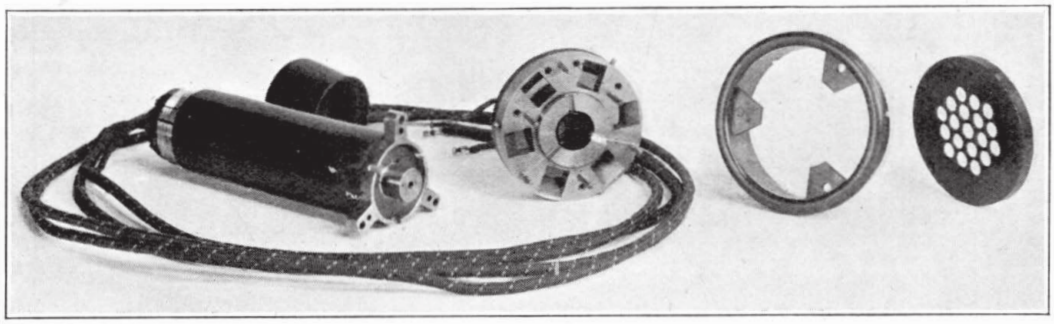


FIG. 8*a*.—RECEIVER PARTS.

coil and consequent air damping. For the same reason the outer case of the receiver is cut away so that there is very little air damping produced, and the control on the moving coil is primarily due to inertia.

The annular field is uniform and extends well above and below the moving coil winding, so that small changes in the position of

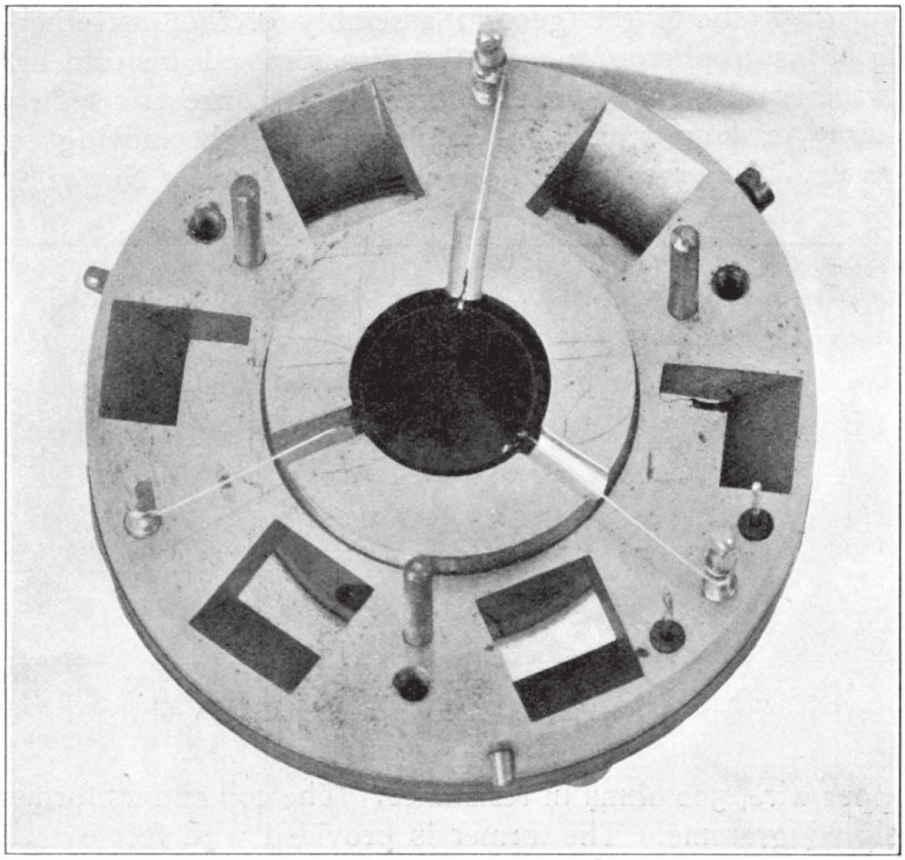


FIG. 8b.—ENLARGED VIEW OF RECEIVER COIL MOUNTING (BACK).

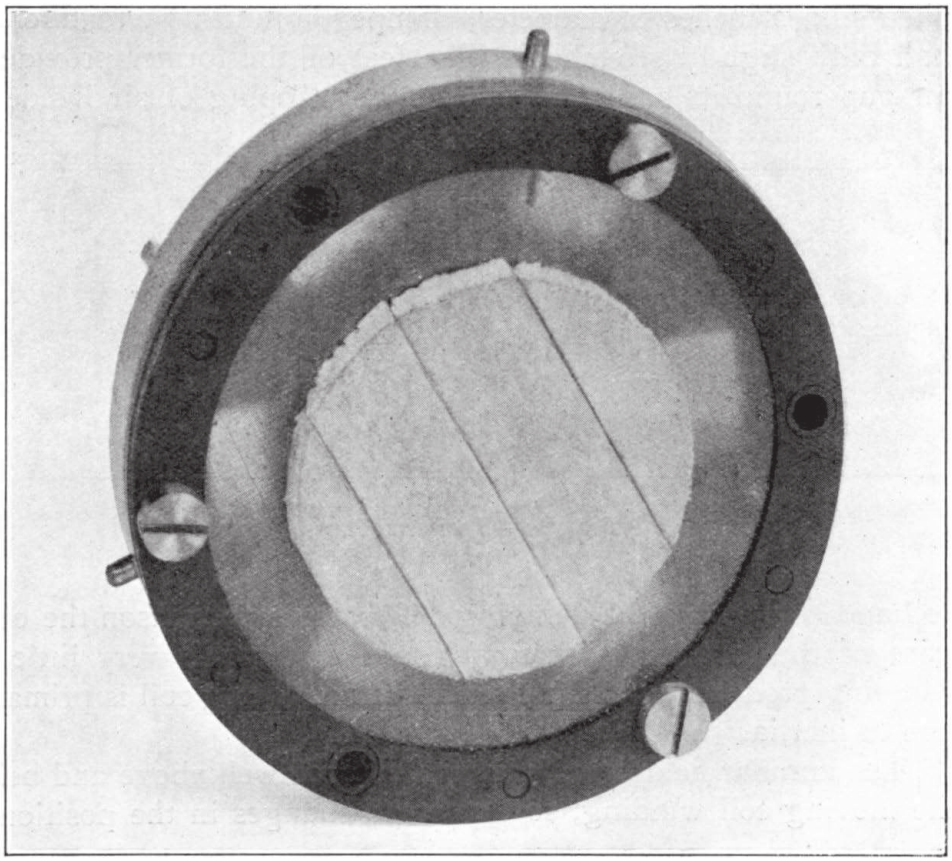


FIG. 8c.— ENLARGED VIEW OF RECEIVER COIL MOUNTING (FRONT).

the latter do not affect the receiver output efficiency. The field magnet is saturated with about 100 milliamps through its winding. To prevent the moving coil tilting in the field and touching the poles, it is supported at its lower end by three fine wires fixed radially. A perforated ear rest is supported on three pillars at a distance of about $\frac{1}{4}$ inch from the pith disc. There are such a number of perforations in this guard and its distance is such that the acoustic loading introduced by its presence is not appreciably altered by the application of an ear to the guard.

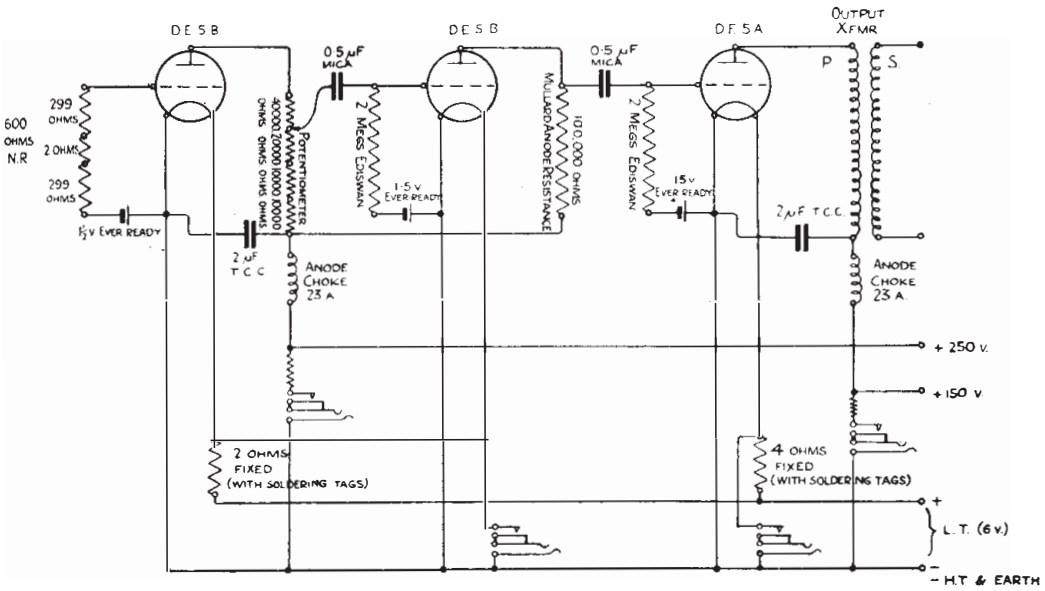


FIG. 9.—RECEIVER 3-STAGE AMPLIFIER.

Fig. **9** is the circuit of the 3 stage amplifier to which this receiver is connected. It is mounted on a separate rack in the same way as the transmitter amplifier. There is no input transformer at present, but the impedance of the grid circuit of the first valve is made equal to that of the non-reactive line by shunting with a 600 ohms non-reactive resistance. It will be observed that the centre 2 ohms of this resistance is tapped. This is for calibrating purposes.

The output transformer has a step down of 3.75 : 1 and is somewhat on the lines of the output transformer on the transmitter amplifier. The receiver impedance is of the order of $500 \angle 10^{\circ}$ for the audio frequency range.

Fig. **10** is the characteristic of the moving coil receiver together with its amplifier. It will be observed that the moving coil system has a resonance at a low frequency and that apart from some small fluctuations which appear to be due to acoustic reflections between the guard and the diaphragm the electro-acoustic ratios p/E gradually fall off from about 3.2 at 500 p.p.s. to 1.0 at 4500 p.p.s.,

or a 3 : 1 ratio which converted to aural sensations may be taken as a range of 1.5 : 1.

For purposes of comparison a typical 60 ohms Bell receiver characteristic is also plotted in dotted lines. This is the characteristic under the conditions of acoustic damping existing when the receiver is placed against the ear.

It is the intention to further improve the receiving circuit by modifying the amplifier and its transformers so that it has a rising characteristic, in order to compensate for the falling characteristic of the moving coil receiver.

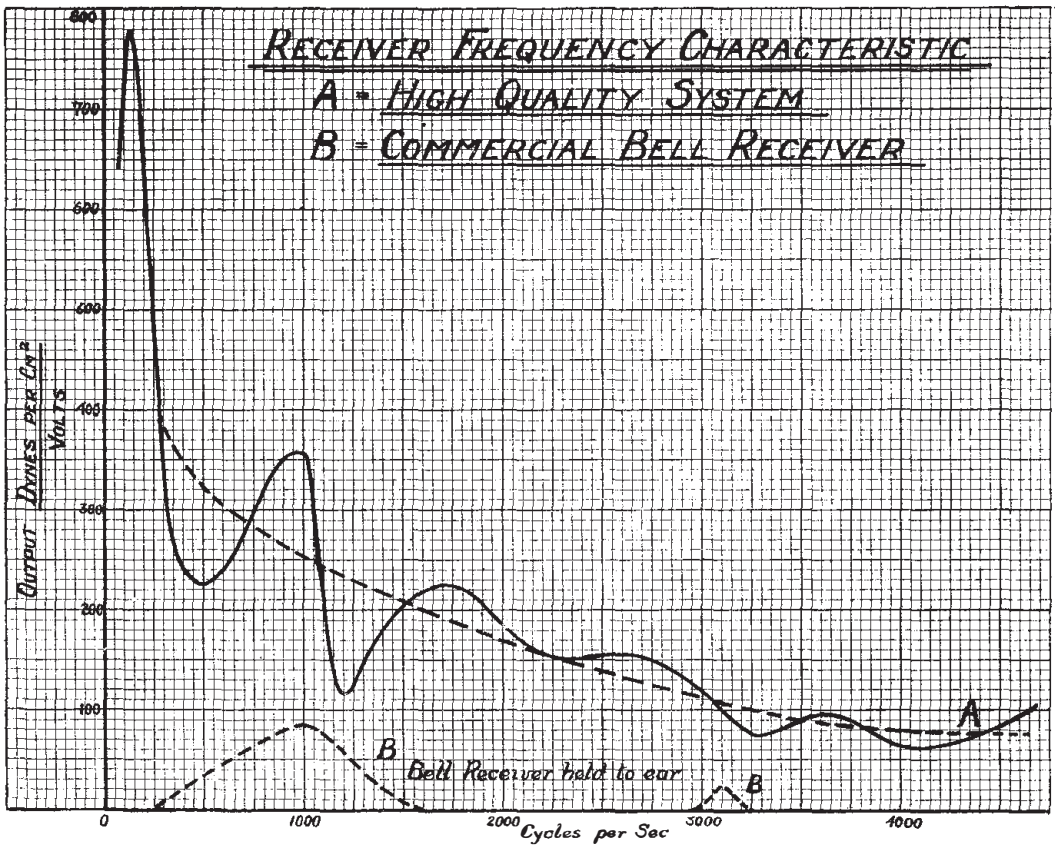


FIG. 10.—FREQUENCY CHARACTERISTIC OF RECEIVER AND AMPLIFIER.

An interesting series of tests to demonstrate the comparative articulation efficiency of this high quality set has been carried out. Articulation tests have been made in the usual manner by reading lists of monosyllabic sounds and taking a mean value for percentage of sounds correctly recorded by 3 observers carrying out 6 tests.

The volume transmitted in this test has then been reproduced for direct transmission in an almost empty room between the same speakers and listeners and also in the open air. The balance was obtained by regulating the distance apart of the speaker and listener, the volume of the former's voice being kept the same as

when using the high quality set. Under these conditions a similar articulation test was carried out and the average percentage correctly recorded for direct transmission in open air and room was 97% and the corresponding figure for the High Quality System was 96%. This should be compared with about 60%, which is the value obtained with a Standard C.B. transmitter connected to a Bell receiver by a high quality non-reactive line equivalent to 30 miles of standard cable (27.7 T.U. or 3.2*b*).

In conclusion it should be stated that the reference system of Telephone Transmission, whose proposed adoption as the Master Standard was mentioned in the last issue of the Journal, and which was designed in the Bell Telephone Laboratories, whilst being of the same order of high quality as the apparatus described in this article, has in addition the following attributes: (1) Proved stability in use. (2) It is completely self-contained with acoustic and electric calibration apparatus.

It is to be anticipated that a complete description of the Master Reference Standard will be published in due course by the Bell Telephone Laboratories and that it will then be possible to publish a full description in this Journal.

JUBILEE OF THE TELEPHONE.

INTERESTING CELEBRATIONS AT THE INSTITUTION AND AT THE SCIENCE MUSEUM.

It is fifty years since the world's first telephone message was sent from one room to another in a house in Boston, U.S.A., by Mr. Alexander Graham Bell. The jubilee of the telephone, the memory of Mr. Graham Bell, and the developments of the past half century were fittingly celebrated by the Institution of Electrical Engineers on the 24th June, when Sir William Mitchell Thomson spoke at a jubilee luncheon and Sir Oliver Lodge lectured to members of the Institution.

The luncheon, which was held at the Hotel Cecil, was attended by a thoroughly representative gathering of electrical engineers, and it was pleasing to note the presence of many P.O. representatives. Unfortunately the Engineer-in-Chief was unable to be present owing to his attendance at the International Conference at Paris. Among those supporting Mr. R. A. Chattock, the year's President of the Institution, at the top table were the following:—The Rt. Hon. Sir William Mitchell Thomson, Postmaster-General, The Rt. Hon. Lord Gainsford, Sir Ernest Rutherford, Sir Oliver Lodge, Senatore G. Marconi, Professor Fleming, Sir Wm. Henry

Ellis, President of the Civil Engineers, Wing Commander C. W. Nutting, Air Ministry, Lieut.-General Sir J. S. Fowler, Royal Corps of Signals, J. H. Jeans, Esq., Secretary of the Royal Society, J. C. W. Reith, B.B.C., and Dr. W. H. Eccles, together with the past presidents of the institution. The luncheon was also graced by the presence of many ladies.

A Record of Progress.

Looking back over the last half century, said Sir William Mitchell Thomson, the telephone deserved to be ranked as among the greatest of the contributions of science to industry. It was hardly too much to say that the telephone had now become a practical necessity to civilised life. Last year we installed as many telephones as were installed during the first twenty years of the development of the telephone. The jubilee of the telephone coincided with a number of interesting events in its development. He hoped it would coincide with the installation and completion of the first large London telephone automatic exchange. In the second place it would coincide with a deliberate and co-ordinated effort to improve international telephone facilities in Europe. There was just being completed a new submarine cable to Holland with twelve speech channels, which would bring the cities of Germany into complete telephonic touch with this country. Later in the year a new cable was to be laid to France with 21 speech channels, and a similar one to Belgium. The third event of the jubilee year was that for the first time they had covered such a distance in their experiments that ordinary two-way trans-Atlantic telephony was well within sight.

At a subsequent gathering in the Lecture Theatre of the Institution in Savoy Place, Sir Oliver Lodge lectured upon "The History and Development of the Telephone," and the Faraday Medal of the Institution was presented to Colonel R. E. B. Crompton as a mark of his lifelong work in the electrical industry.

If asked suddenly what was the simplest and greatest invention of the nineteenth century, he would be disposed to say the telephone, said Sir Oliver Lodge. The articulating telephone was an instrument of absurd simplicity. It was invented by one who was not a professed electrician, who was not really learned in physical science, but was interested mainly in introducing precision and clear intelligibility into human speech. Most people in talking slurred over words in a careless and barely intelligible manner. Clear utterance was never a strong point of the pulpit, though it used to be prevalent on the stage. (Laughter.) Even that could hardly be said now. Graham Bell's own articulation was of the most precise character. He had been concerned in the

training of the deaf and dumb, he had married a deaf and dumb wife, and devoted himself to the accurate production of human speech, whether by his own lips and larynx or through its reproduction by instrumental means. He once said that it was fortunate he was not a scientifically trained physicist, for if he had been he would probably have thought that an articulating machine of a simple character was an impossibility.

"It is difficult to exaggerate the delight with which the telephone was received," said Sir Oliver. "In these days it is occasionally customary to regard the telephone as a nuisance, and so I found it in America in 1920. At any time, day or night, I might be called up. It was little use telling the hotel clerk not to switch people on. They got through any ordinary barriers, and when too much bored, my plan was to turn the receiver on to the transmitter and let the communicator talk back to himself—a plan which was usually effective. It was also said that Bell himself found the telephone a sort of nuisance, and had it removed from his room." (Laughter.)

Sir Oliver gave a most interesting description of his bringing the first receivers to this country and explained how a fault in the diaphragms threw light on the theoretical and practical operation of the apparatus. He was applauded enthusiastically by the crowded audience at the close of his address.

Conversatione and Exhibition.

In the evening a large company of members and their friends attended the annual reception by the President in the Science Museum, South Kensington.

By the courtesy of Colonel H. G. Lyons, F.R.S., Director of the Science Museum, and Colonel T. F. Purves, O.B.E., Engineer-in-Chief of the General Post Office, an Exhibition was arranged on the First Floor (Gallery XXVI.) of a representative collection of telephone apparatus of historical interest. The exhibits included the following:—

1. *Original Reis Telephones.* The first electric apparatus for the transmission of sound was invented by Philip Reis, of Friedrichsdorf, in 1863, and called by him a "telephone." The apparatus was not, like Bell's, a speaking telephone.
2. *Early Bell Telephones.* One of these instruments is very similar to that exhibited by Graham Bell at Philadelphia on June 25th, 1876. The diaphragm is of goldbeater's skin and has at its centre a piece of cork to which is attached an armature. Two subsequent forms of the Bell telephone are also shown.
3. *Original Hughes Microphones.* A selection from the original

apparatus made and used by D. E. Hughes in connection with his discovery of the microphone in 1878.

4. *Edison Carbon Transmitter.* The main features of this—the first commercial application of the carbon transmitter—were patented by Edison in 1877.
5. *Early Telephone Instruments.* A selection showing the evolution of the present-day telephone from the original apparatus of Bell, Hughes and Edison.
6. *Telephone Switchboards.* A series of manual switchboards from 1888 to the present day.
7. *Automatic Telephone Apparatus.* Some of A. B. Strowger's original instruments, and also working models of the automatic telephone systems for London and the Provinces which may be inspected and operated.
8. *Telephone Repeaters.* Models of two-wire and four-wire trunk telephone repeaters (in operation).
9. *Trunk Testing Equipment.* Apparatus used by the General Post Office for measurements on trunk telephone lines.
10. *Samples of Submarine and Underground Telephone Cables, Etc.*

TIME SAVING TESTERS.

FOR AUTOMATIC EXCHANGES.

By W. PRICKETT and H. S. SMITH
(Engineer-in-Chief's Office).

THAT a selector is not of much use without its bank is a truism, but in the consideration of the testing-out of automatic exchange equipment, tests of the switch functions are apt to overshadow those of the uninteresting, but no less important, banks. In the past the latter have, in the main, been tested by means of a buzzer and battery, a method more productive of eyestrain than accuracy. The time which this method occupied was enormous while the results were disappointing, for such faults as high resistance contacts between adjacent lines, contacts between adjacent levels and failure of the switch wipers to make satisfactory connections with the bank circuits were not detected.

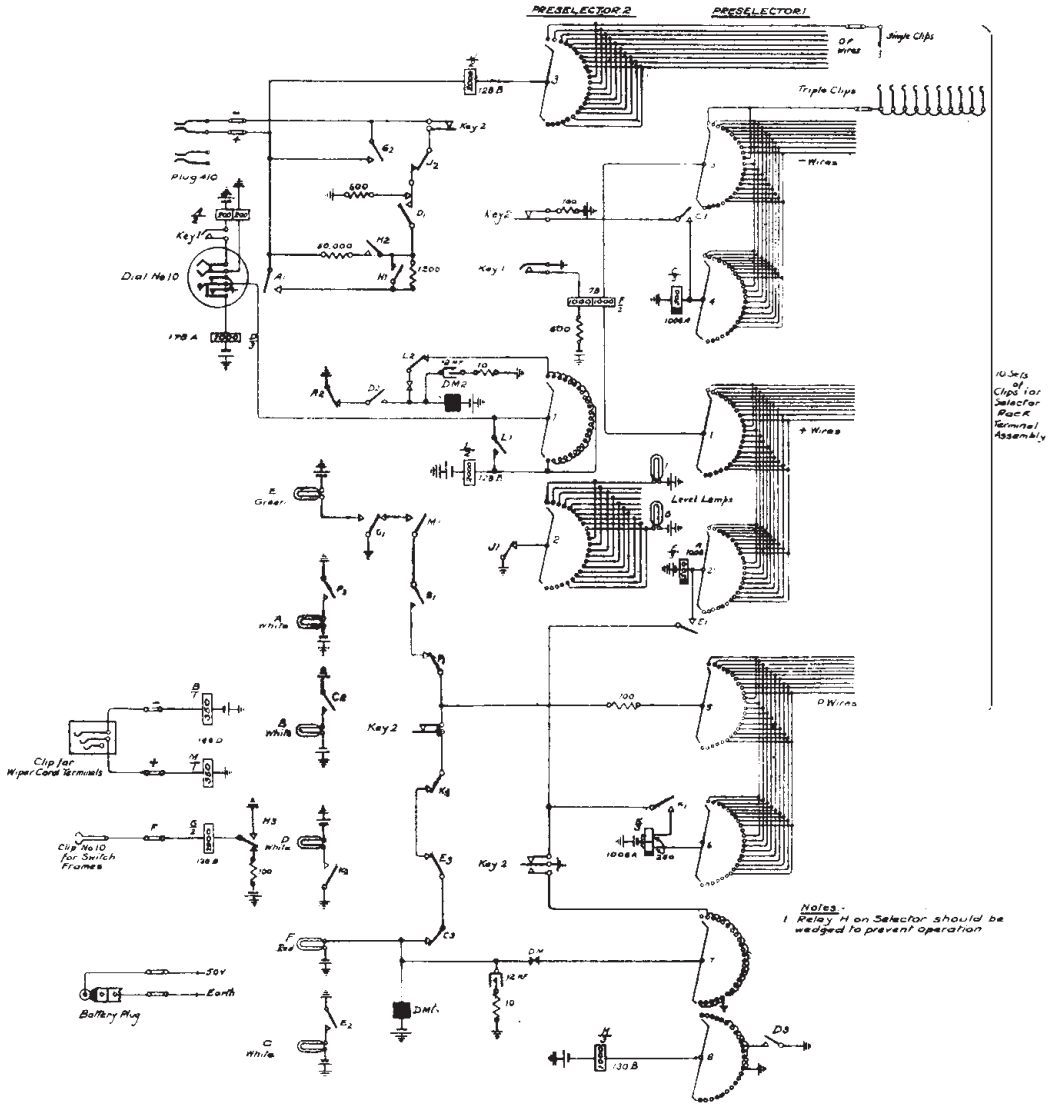
Alternative methods had, therefore, to be adopted to deal with faults not covered by the simple tests for continuity.

In an exchange such as Holborn Tandem there are about seven thousand group selectors and the time taken to "buzz out" their banks would approach 3500 man-hours. The advent of a tester

which enabled the testing of these banks to be completed in one-tenth of this time was, therefore, welcomed by those who had had experience of the laborious task of performing these tests by the old method.

This tester, which will now be described, applies tests not only to replace the "buzzing-out" but many others to cover the deficiencies of that method, with the result that before the exchange is opened for service, faults are discovered which might cause much trouble.

In addition to the bank test, which is the primary object of the design, an effective operating test of the selectors is made without additional expenditure of time.



CIRCUIT OF TESTER N.

TESTER "N."

Tester "N," a circuit diagram of which is here reproduced, consists of a few relays and two preselectors, together with the

means of connection to the bank wiring and the switch to be tested.

The equipment contractors have arranged to run the grading wires the whole length of the selector rack terminal assembly, thus commoning all the banks and to leave the jumpers disconnected until the completion of the tests. The ten outgoing circuits from each level of the banks are connected, one level at a time, as the test on the first switch proceeds, in parallel with the circuits from the other levels, by means of the ten sets of ten triple clips provided. These clips are connected in the tester to the bank of an eight level preselector. In addition the eleventh ("O.F.") contacts of each level are connected, by means of the ten single clips provided, to the bank of the second preselector in the tester.

The test plug is inserted in the test jack of the first selector to be tested and the + and − clips are attached to its wipers.

A clip is also provided for attachment to the bank rod or frame of the selector under test.

Relay H of the selector is wedged in order to prevent operation and Key 2 depressed, if necessary, to set preselector 1 to contact 1. Key 1 is also operated. The latter causes relay F to be energised *via* its polarising winding and also operates the impulsing relay A.

The dial is now operated to step the selector under test to level 1.

Immediately the dial is moved off normal, relay D operates to connect the impulsing loop at D1 op. An earth is also applied to wiper 1 of preselector 2, causing the latter to rotate home in readiness for indicating the level dialled. The circuit is from battery, *via* DM2, interrupter springs, L2 nor., bank and wiper 1 to earth at the dial. When the wipers reach contacts 11 or 25, relay L operates and locks to the same earth, thus disconnecting the homing circuit at L2 op.

On the release of the dial, relay A responds to the impulses transmitted, and repeats these impulses to the selector under test *via* A1, and to DM2 *via* A2 and D2 op. Preselector 2 steps round to the contact corresponding to the number dialled and causes the appropriate level indicating lamp to glow *via* wiper 2 and J1 nor.

The selector should now step up to the required level and cut in to the first contact on the bank.

Relay D, releasing when the dial returns to normal, completes a holding circuit to the − line of the selector *via* D1 nor. and 600 spool to earth. A circuit is now completed for relays M and B *via* the + and − bank wires, arcs 1 and 3 of preselector 1 and relay F.

Receipt of a current of correct strength and polarity by relay F causes the latter to release and complete the circuit of DM1 *via* F1 nor., B1 op. and M1 op. to earth at G1 nor.

This earth is also connected *via* the 100 spool and arc 5 to the P wire, causing the selector relay G to operate and step on the switch to the next contact.

The circuit for relays B, M and F is now broken and DM1 steps on when its circuit is interrupted at F1 op.

The sequence of operations is repeated on the remaining contacts of the level until the selector comes to rest with its private wiper on the eleventh contact, and its cam springs operated to give the busy signal.

If the latter is correct, battery is received *via* the + line by relay J, which is connected to earth at the selector *via* wiper 3 of preselector 2, O.F. clip 1 and the eleventh contact on which the switch wiper is resting. Each battery period of the busy signal operates relay J, which flashes the level lamp at J1 op. At J2 op., the holding circuit is disconnected in order to test the selector for the "busy hold" feature. The latter is faulty if the switch releases.

If the lamp, corresponding to the dialled level, flashes correctly three times, it may be assumed that the required level has been successfully tested and the selector should be released by the depression of key 2.

In addition to the foregoing a test is provided on each bank wire for contact with the adjacent wire. This is effected by relays C, E and K, which are connected *via* arcs 4, 2 and 6 to the required lines adjacent to those under the previous test.

A contact causes the appropriate relay to operate and lock *via* its own contact.

Lamps B, C and D are provided to indicate this condition and are operated *via* contacts C2, E2 and K2 respectively. The rotation of preselector 1 is also interrupted at C3, E3 or K3, and attention is drawn to the fault indicated by the stopping of the tester.

A further test for earth or battery in contact with the switch or bank frame is provided by relay G, which is alternately connected to battery and earth by the operation or release of relay H at arc 8. A fault of this nature is indicated by lamp E, which glows *via* G1 op., and by failure to impulse or stopping of the test. If, however, it is an eleventh contact which is framing, the fault is indicated by failure to release on operating key 2. Relay H also changes over the dialling conditions from a 1200 ohm loop to a zero loop for alternate tests.

The position in which preselector 1 stops usually indicates the corresponding contact of the selector bank on which a fault exists. In certain cases, however, a departure is made from this condition, but reference to the table following will enable the testing officer to decide where the fault is located :—

Nature of Fault.	Wire.	Indicating Lamps.	Position of Wipers. (On fault unless otherwise stated).	
			Preselector Contact.	Selector Contact.
Dis.	–	A	–	–
	+	A	–	–
	P	F	–	–
Earth	–	A	–	–
	+	ABC (except Contact 1)	One before fault	–
		None (Contact 1)	–	–
	P	AD (except Contact 1)	One before fault	One past fault (On fault if high res.)
		ABC (Contact 1)	–	
	– & + (S/C)	AB (except Contact 1)	One before fault	–
		A (Contact 1)	–	–
	– & P	ABC	One before fault (except Contact 1)	–
	+ & P	A	–	–
Contact	Adjacent – & –	ABC	– (1st line)	– (2nd line)
	+ & +	ABC	– ,,	– ,,
	P & P	ABCD	– ,,	– ,,
	P & OF	A	1 (or II)	Premature Release
	Frame & OF or Eth.	AE	1 (or II)	
Reversal	– & +	A	–	–
	– & P	–	–	–
	+ & P	A	–	–

Lamp F also gives warning in the event of the Tester Preselector 1 being held continuously operated.

REMARKABLE VITALITY OF A P.A.B.X. EQUIPMENT.

A REMARKABLE instance illustrating the ability of modern telephone plant to withstand the most adverse conditions has recently occurred in Lancashire, where a Private Automatic Branch Exchange equipment installed in the basement of a cotton mill was inundated by the floods consequent upon an exceptionally severe thunderstorm.

The charging machine, ringing machine, one battery of secondary cells and practically the whole of the automatic equip-

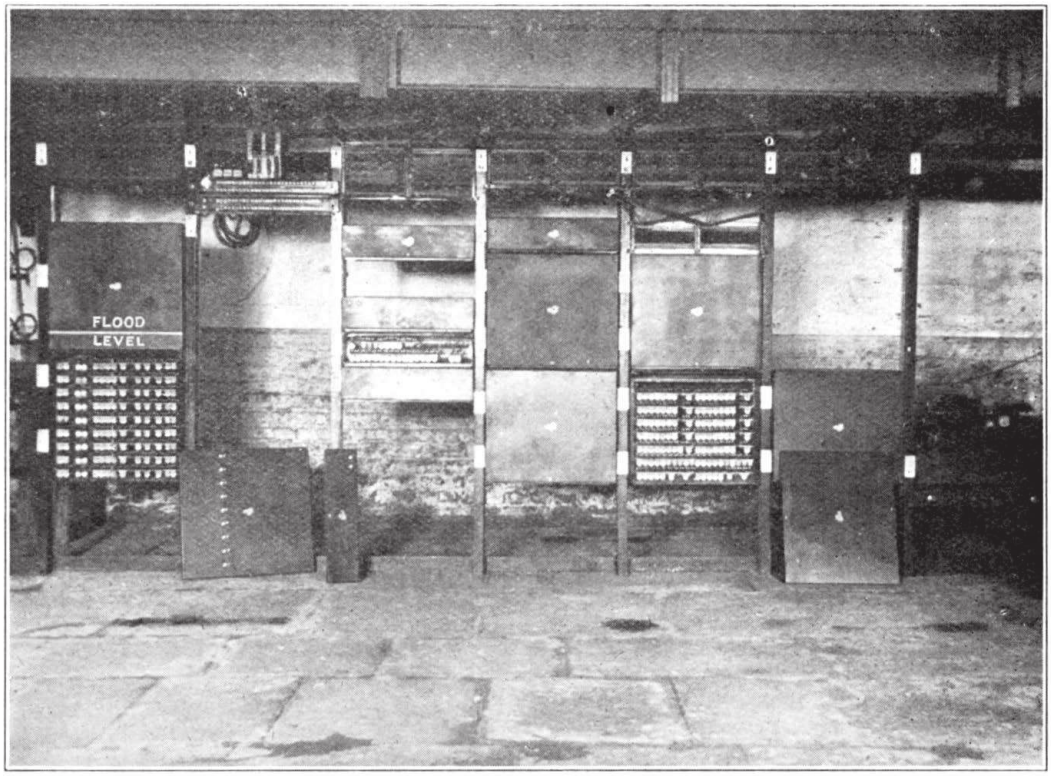


FIG. 1.—APPARATUS RACK SHOWING FLOOD LEVEL.

ment were submerged. The flood occurred late one evening and no steps to restore the service could be taken until the storm had abated, when a fire engine was employed to empty the basement, which had been filled to a depth of about 4 feet.

From 2 to 3 inches of mud was left on the floor, and besides being soaked with water the apparatus was found on removing the relay covers to be smothered with a film of slime and green rubbish.

Although the position appeared hopeless, the idea of salving the equipment was formed, and as a first step in this direction

a hose was connected to a hydrant and turned on the apparatus to wash away the filth; any mud remaining after washing with the hose was removed from the relays and cable forms by the use of Pyrene fire extinguishers. The washing completed, the standing water was mopped up and all surfaces were wiped with clean cloths. The machines, after further washing and wiping, were dismantled and placed in the boiler house to dry.

Two sets of secondary cells were fitted at different levels on a rack. The lower set was submerged and left partly filled with mud, the electrolyte having mingled with the waters of the flood. To restore the cells to service they were emptied, cleaned and

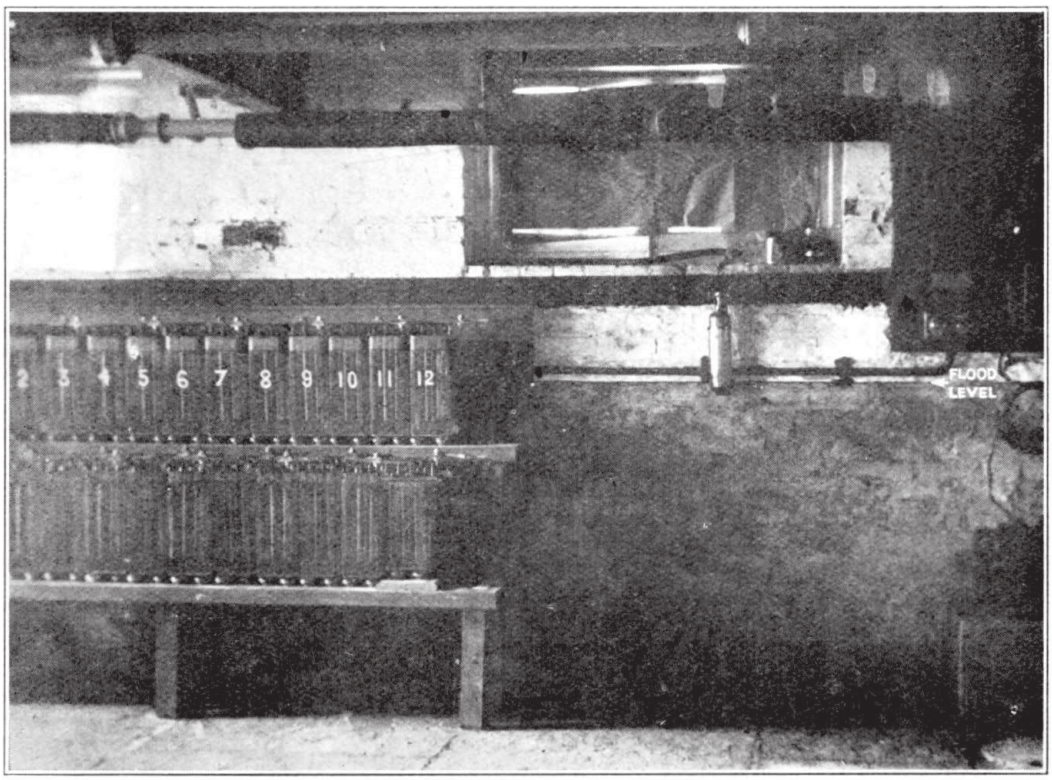


FIG. 2.—BATTERY SHOWING FLOOD LEVEL.

refilled with acid and, pending the availability of the charging dynamotor, they were charged through a resistance direct from the mains.

The ordinary heating apparatus of the room was brought into use, but this was found to be quite inadequate if the water were to be evaporated before the plant was damaged by corrosion. A motor desiccator, a number of blow lamps and as many electric radiators as could be obtained were brought into use. The most efficient way of removing the moisture, however, was found to lie in the use of "Vacuum cleaners" reversed and used as blowers,

with the suction sides arranged to draw the heated air from blow lamps through 6" diameter metal tubes in which were placed bags of calcium chloride. As much as possible of the water standing on the relay springs and other parts was removed by the use of blotting paper and the cable forms that had been submerged were opened and boiled out with wax.

Attention was then directed to the reconditioning of the automatic apparatus in detail, the work being carried on continuously day and night. It was necessary to brush and clean the various parts of each relay before any regulation or adjustment could be made. All relay armatures were removed and cleaned, every contact throughout the equipment was cleaned, and every spring was tested for tension and adjusted if necessary.

Immediately following the flood notice had been given to the manufacturers (the Relay Automatic Telephone Coy.) of the possibility of a demand being made for plant to replace the damaged equipment, but, thanks to the quality of the original apparatus and to the initiative and the persistent efforts of the staff, the installation, as it stood, was restored to service on the morning of the seventh day after the flood.

600 relays, one set of secondary cells, one charging machine, one ringing machine and the associated wiring and cabling were submerged, but with the following exceptions the whole of the plant was salved and is still in use. The exceptions were one choke coil and 3 transformers in the ringing equipment and 8 relays and 4 condensers in the automatic switching equipment.

The protector cases were also flooded, but on the morning after the flood the subscriber was given service to the exchange and to some of the extensions through the Manual Board situated on the floor above. This partial service was continued until complete restoration.

Some idea of the conditions prevailing after the flood may be gained by the fact that the staff found it desirable for the first two days to work in Wellington boots, which were supplied to them by the subscriber.

The local staff who carried out the whole of the work can be heartily congratulated on the result, and it is pleasant to record that the appreciation of the Engineer-in-Chief was conveyed to each man who had so wholeheartedly worked to achieve success in what, for a few days, seemed an impossible task.

Twelve months have now elapsed since the flood, and the occurrence of faults in the automatic apparatus has been at the rate of one fault per circuit per annum, a figure which, although about four times as great as the normal for this type of installation, cannot be regarded as high in the circumstances described.

THE TUNGAR RECTIFIERS.

By H. C. Jones, B.Sc.

In view of the increasingly large number of small telephone installations such as P.A.B.X.'s, C.B.S. No. 2 and C.B. 10A

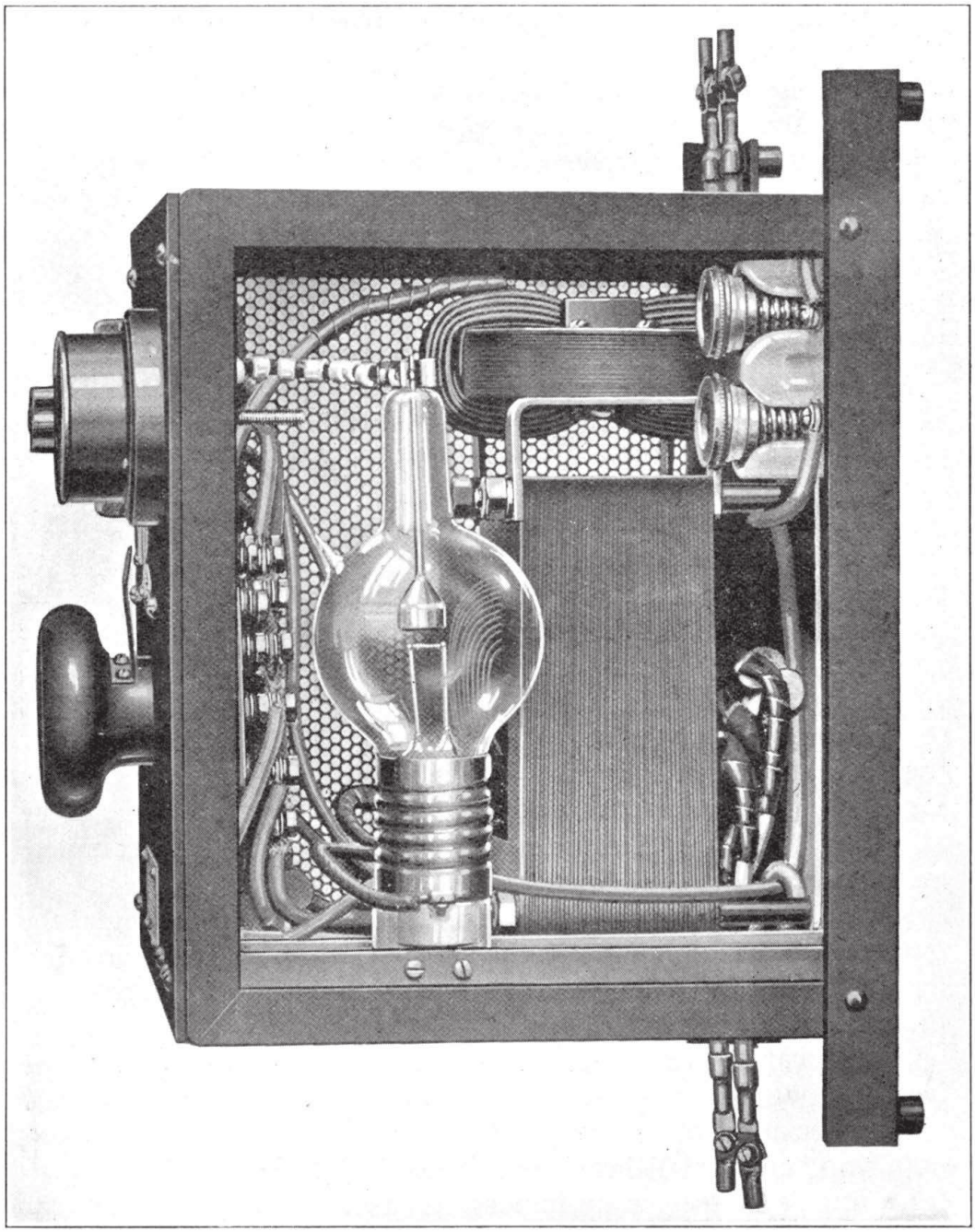


Fig. 1.—Internal view of Half-Wave type, Tungar Rectifier.

exchanges which require secondary cell power plant, it has become necessary to standardise suitable apparatus for charging small

capacity secondary batteries from alternating current mains. Trials have been made with rectifiers of various types, such as the ordinary motor-generator set and the aluminium lead electrolytic cell, and an investigation is now being carried out on the tantalum lead cell, but up to the present the thermionic valve type has proved to possess several important advantages which have resulted in its being adopted as a standard. Between three and four hundred of these machines are now in operation in all parts of the country and it is thought a brief description of the apparatus may prove of general interest to all and of use to those who have thermionic valve rectifiers under their care.

The machine most generally used by the Department is the "Tungar Rectifier." There are two standard sizes, one using a

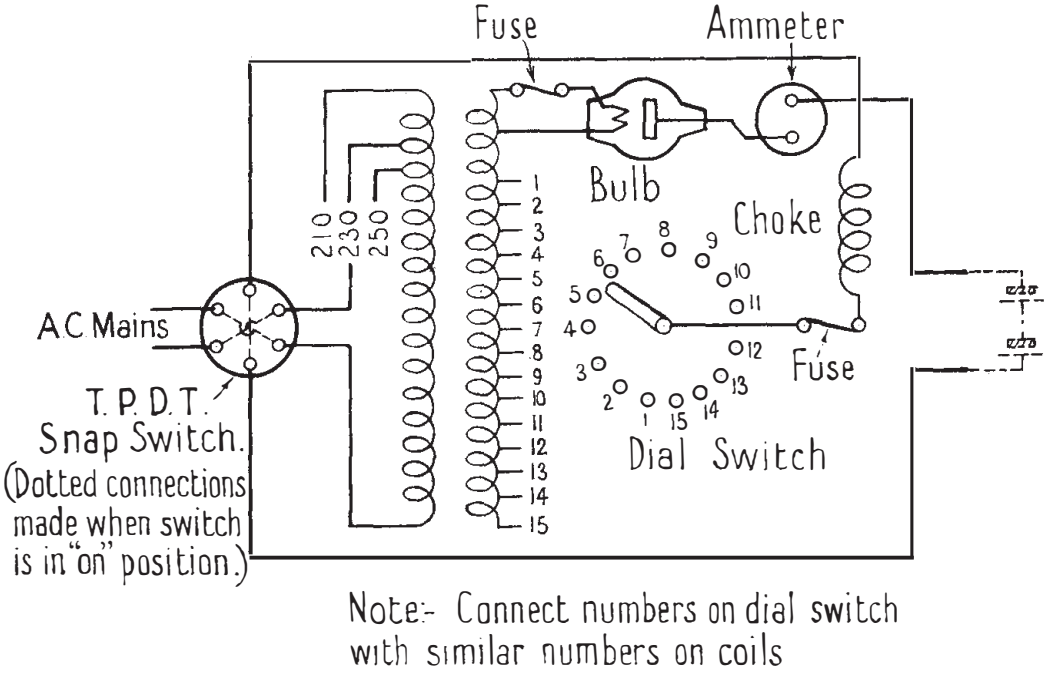


FIG. 2.—CONNECTIONS OF HALF-WAVE TYPE, TUNGAR RECTIFIER.

single bulb and giving an output of 10/70 volts 6/5 amps; the other, which rectifies the whole wave, having two bulbs and giving an output of 10/70 volts 12/11 amps. Each size can be wound suitable for any electric supply between 100/250 volts and 25/100 cycles.

Considering first of all the single bulb model which is illustrated in Fig. 1 and the circuit diagram of which is shown in Fig. 2, it will be seen that its chief components are a transformer and a two electrode valve, upon which the operation of the rectifier chiefly depends. The type in most general use is that suitable for a supply of 200/250 volts, 40/50 cycles. The transformer of this machine

has three tappings on the primary, suitable for 210,230 and 250 volt supplies. The secondary is tapped in 15 places and by means of a regulating switch it is possible to obtain a range of voltage between 25 and 90 across its terminals. This variation is necessary so that the apparatus may be capable of charging batteries containing any number of cells between 6 and 30.

The bulb (see Fig. 3) has a thick, low tension filament wound in the form of a spiral which, when it is screwed into its socket, is tapped across a small portion of the transformer secondary. It also contains a graphite electrode which forms the anode of the bulb. During manufacture, the bulb is exhausted to the highest possible vacuum and is then filled with an inert gas, argon, to a pressure of about 3 m.m. of mercury. As it is impossible practically to make the argon absolutely pure and as the impurities,

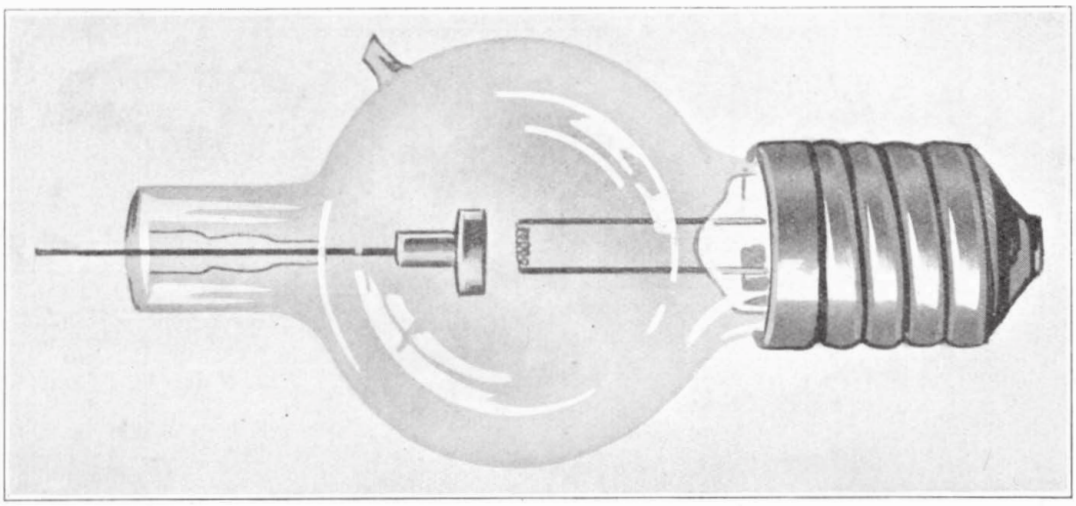


FIG. 3.—THE TUNGAR BULB (SHOWN IN HORIZONTAL POSITION).

if not neutralised, result in the disintegration of the filament and adversely affect the characteristics of the valve, special means are adopted to ensure freedom from these gases when the bulb is in operation. At the time of manufacture, therefore, other substances, principally magnesium, are introduced into the bulb and react chemically with the impurities in the argon. The purifying agent takes the form of a ring wrapped round one of the filament supports, or sometimes round the graphite anode, and the discolouring which appears on the inside of the glass after the bulb has been in operation for a short time is the result of its chemical action.

The principle of operation of the Tungar bulb is similar to that of the Fleming two electrode valve. The filament which is heated to incandescence by alternating current, emits electrons, which are

attracted to the anode, provided the latter is at a positive potential relative to the filament. During their journey across the valve, they collide with the gas molecules and ionise them, thus forming a conductive path from the anode to the filament. Provided the anode is negative relative to the filament, however, the electrons emitted by the latter are attracted back again and under these circumstances the bulb remains non-conductive. The presence of the argon makes the bulb extremely "soft" and not more than 90 volts can be applied to it without the risk of a "flash over," and this is one reason why it is necessary to use a transformer.

Fig. **2** shows that the battery which is to be charged is arranged with its negative terminal connected to the anode of the bulb. As the latter is non-conducting in such circumstances it will be seen

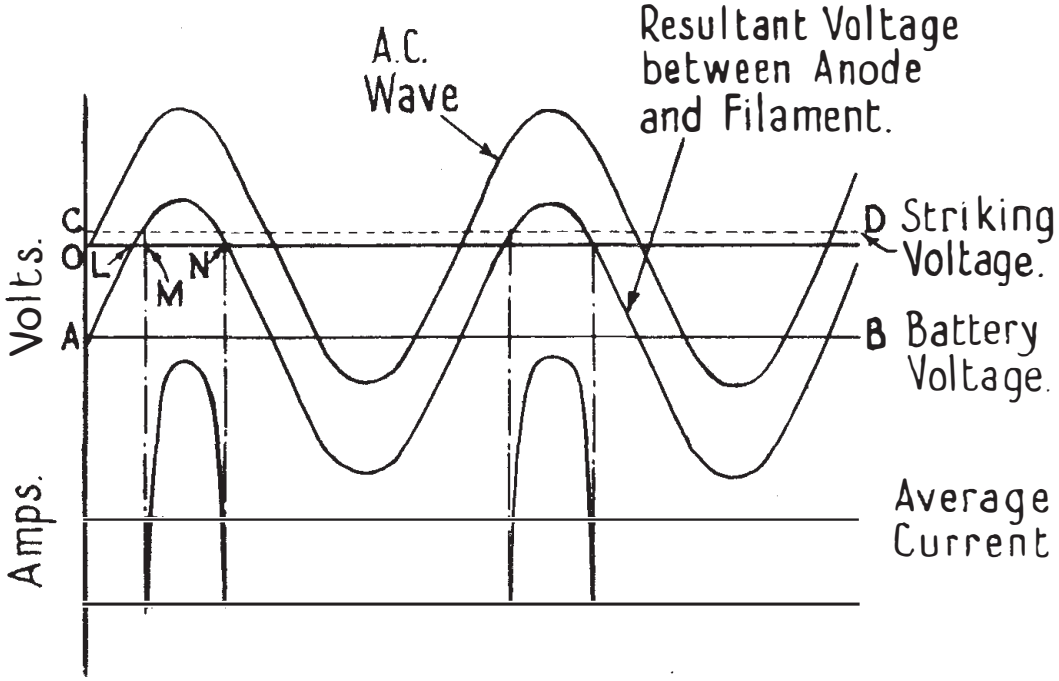


FIG. 4.—CURVES SHOWING PRODUCTION OF CURRENT WAVE.

that until the machine is connected to the mains the battery can neither be charged or discharged. In the event of a failure of the power supply, there is therefore no danger of the battery discharging back, as there is when a motor-generator not fitted with a reverse current circuit breaker is used.

After the alternating supply has been switched on, during every alternate half cycle, the secondary voltage wave will be in a direction such as to oppose the voltage of the battery and consequently if the amplitude of the wave be great enough the anode of the bulb will become positive relative to the filament. When the anode has a potential of about 10 volts positive, the bulb strikes, that is to say, the bulb being in a conductive state, current flows across it

from anode to filament. This current also flows through the battery from positive to negative and thus charges it. Assuming no inductance in circuit the current will cease to flow when the alternating voltage has fallen to that of the battery and therefore only flows for a small portion, usually about 1/3, of the cycle.

Thus, if the current as recorded by a moving coil instrument be 6 amperes the actual peak value may be between 18 and 24 amperes. Tungar Rectifiers as used by the Department, however, are now fitted with a choke coil in series with the charging circuit and this has the effect of prolonging the period during which current flows and reducing the maximum value of the wave.

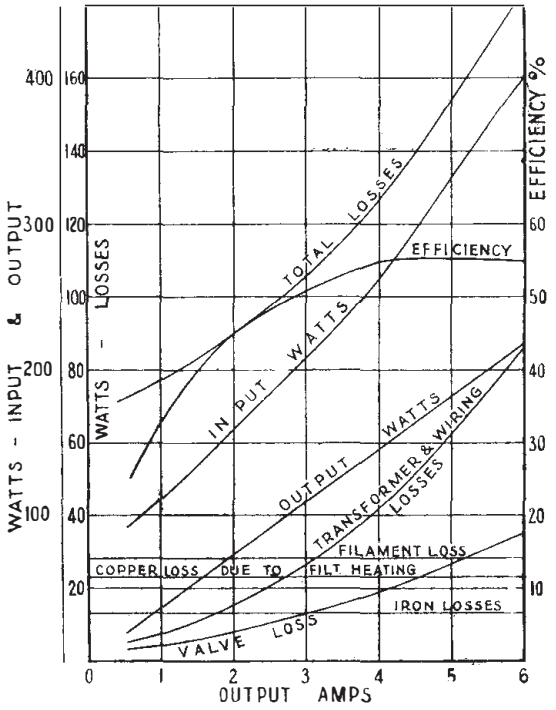


FIG. 5.—CURVES SHOWING LOSSES AND EFFICIENCY OF A TUNGAR NO. 1C WHEN CHARGING A 36V. BATTERY.

The foregoing brief description may be more fully appreciated by a consideration of Fig. 4. The line AB represents the negative voltage on the anode due to the battery. This may be regarded as constant. The top sine curve represents the alternating voltage induced in the secondary of the transformer. The sum of these two curves is represented by the lower sine curve and shows the resultant voltage between the filament and anode at any portion of the cycle. It will be seen that the latter is positive for a small portion LN of the cycle. The line CD represents the striking voltage and current therefore flows for a period MN. The peak voltage on the plate, as shown by this diagram, is actually not obtained in practice for the reason that as soon as current com-

mences to flow a resistance drop occurs between the anode and filament, the voltage being thereby reduced.

An interesting fact arising out of the unusual shape of the current wave is that the various types of ammeter indicate different currents. A moving-coil instrument, of course, measures the average current, which is the figure required in connection with secondary cell work. A hot-wire ammeter, however, which records R.M.S. values, reads considerably more, usually between 1.4 times and twice the figure indicated by the moving coil instrument.

The efficiency of the single bulb Tungar compares very favourably with that obtained with all other types of rectifier of similar

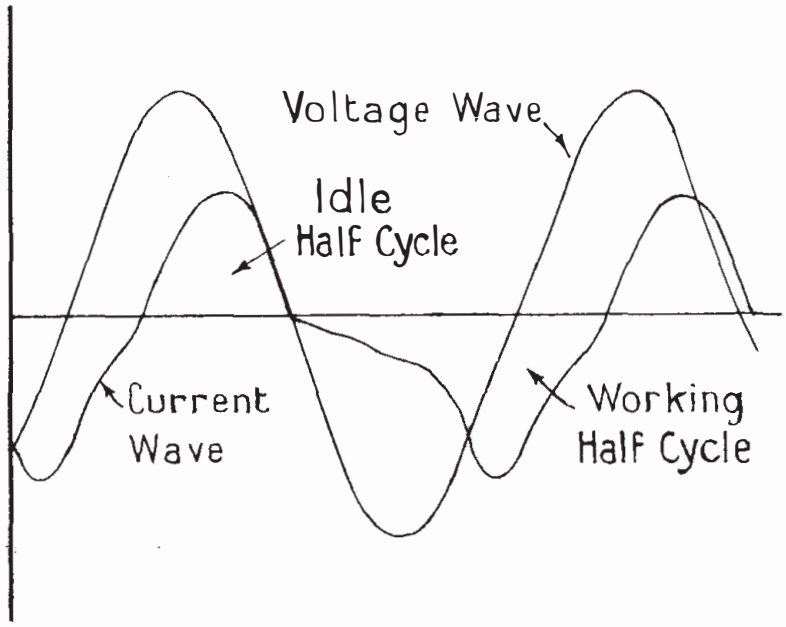


FIG. 6.—INPUT VOLTAGE AND CURRENT HALF-WAVE TYPE.

output. It varies between 28% and 60% according as it is charging a 16 or 60 volt battery respectively at full load current. The losses are as follows :—

(1) Transformer iron losses which are independent of load; (2) Transformer copper losses; (3) Loss due to the heating of the filament and small portion of the transformer winding across which it is tapped; (4) Resistance loss between the anode and filament of the bulb; and (5) Switch and wiring losses. The first and third of these are, generally speaking, independent of the load, whilst the others vary approximately as the square of the load. The curves shown in Fig. **5** give some idea of the magnitude of the various losses and efficiency when charging a 36-volt battery.

An interesting point is that the efficiency can exceed 50%. It would appear at first sight that, as the bulb rectifies alternate half waves and that certain losses also take place, the efficiency must be

considerably less than 50% even when the Tungar is working under the most suitable condtions. During the idle half cycle, however, the secondary of the transformer, with the exception of the few turns which supply power to the filament, is on open circuit and consequently the primary acts as a choke. The current therefore tends to be reduced and to lag considerably behind the

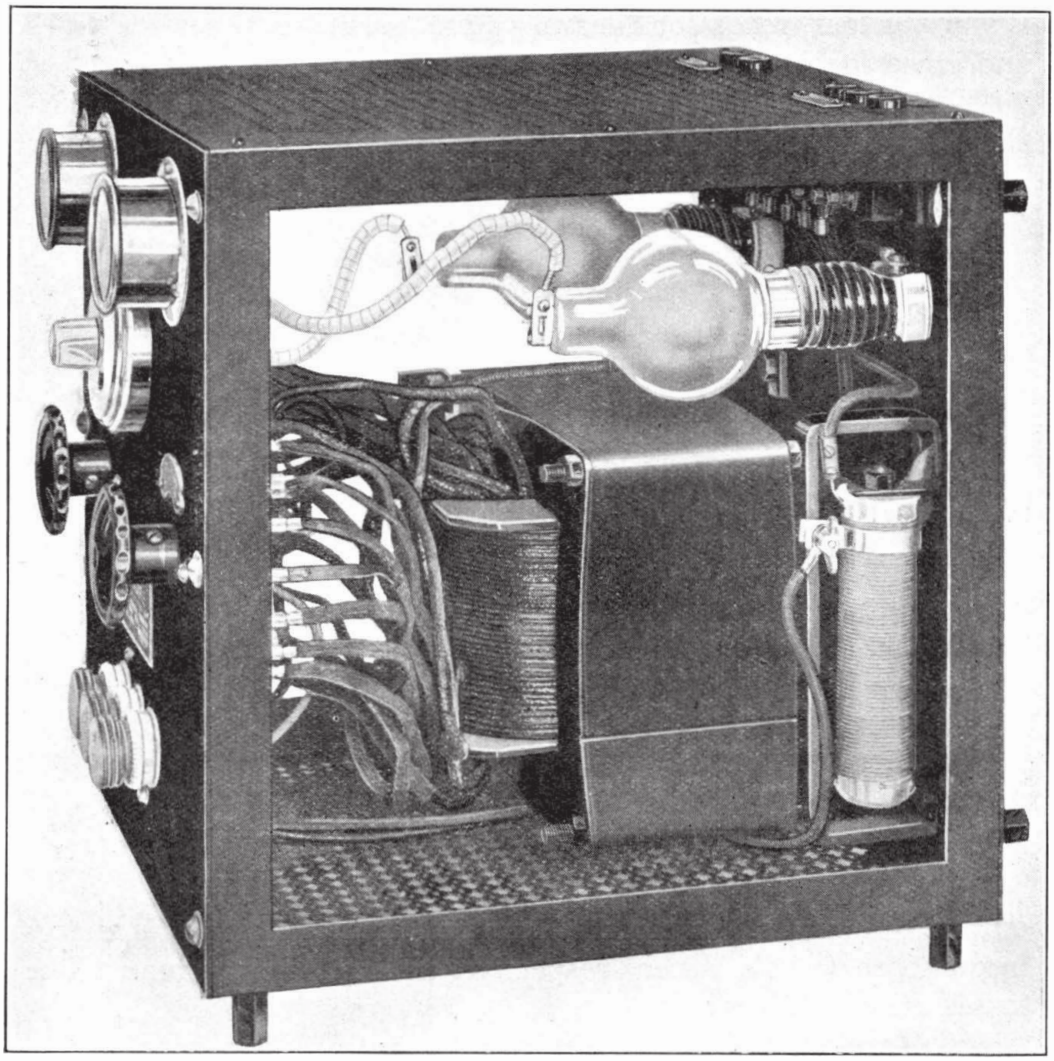


FIG. 7.—INTERNAL VIEW OF FULL-WAVE TYPE, TUNGAR RECTIFIER, 12-AMP.

voltage wave, with the effect that the power in the circuit during the portion of the cycle is reduced and the efficiency increased. This is clearly shown in Fig. **6**, which is a copy of an oscillogram of the primary voltage and current waves.

The only difference between the 6 amp. and the 12 amp. type (which is illustrated by Figs. **7** and **8**) is that the latter has two bulbs and two windings on the secondary of the Transformer. The bulbs rectify alternate half cycles and hence the full wave is

utilised. It might be expected that this would result in the two bulb type having a much higher efficiency than the single valve type, but this is not so, for although the output is doubled, the iron loss, filament, transformer and valve heating losses are also doubled, and the efficiency is therefore not unduly affected.

The output under various conditions is shown in Figs. **9**, **10** and **11**. Fig. **9** shows the nature of the charging current with the choke coils cut out of circuit. The sine curve represents the primary voltage wave and it will be seen that there are two current impulses per cycle. Fig. **10** shows the output of one valve when

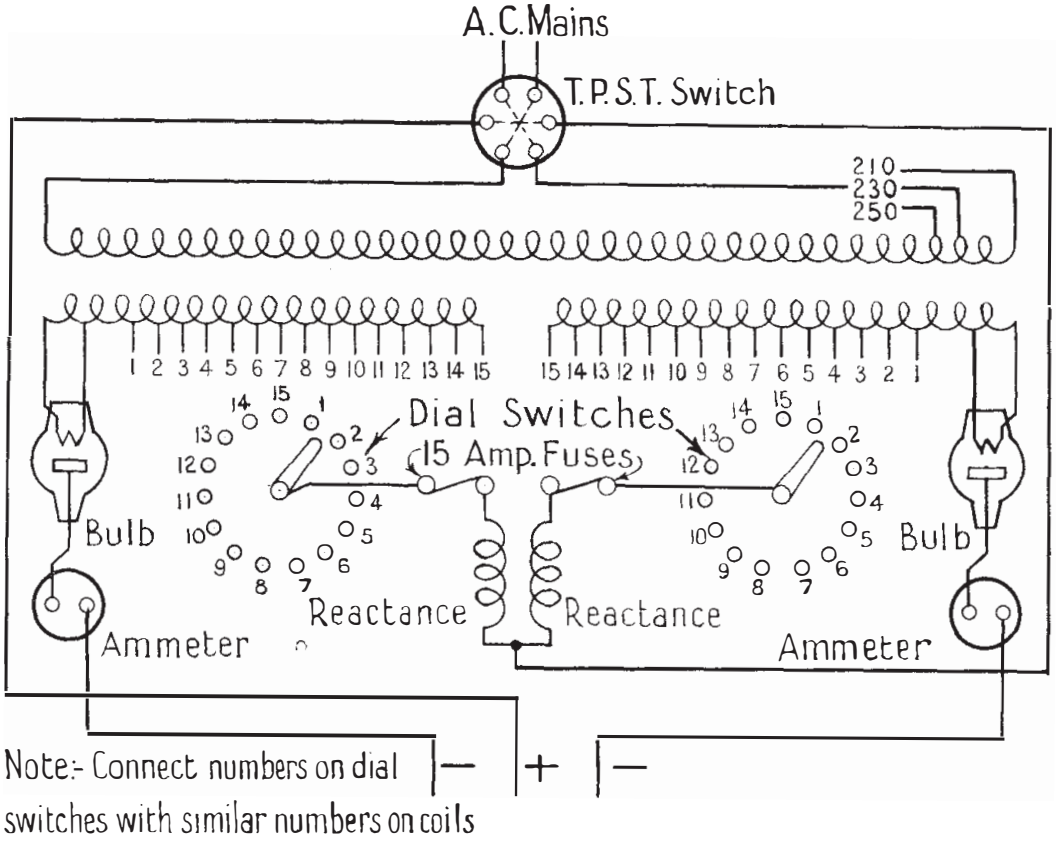


FIG. 8.—CONNECTIONS OF FULL-WAVE TYPE, TUNGAR RECTIFIER.

a choke coil is inserted in circuit and it clearly illustrates the smoothing effect of the latter. Fig. **11** shows the total output of the Tungar. It will be noticed that in this case the peaks have been almost flattened out and an almost uniform direct current produced.

For small telephone installations it would be almost impossible to find a more convenient charging agent than the thermionic valve rectifier. It is only necessary to switch on the power and adjust the charging current and the whole apparatus may be safely left until the end of the charge. If used with an automatic charge

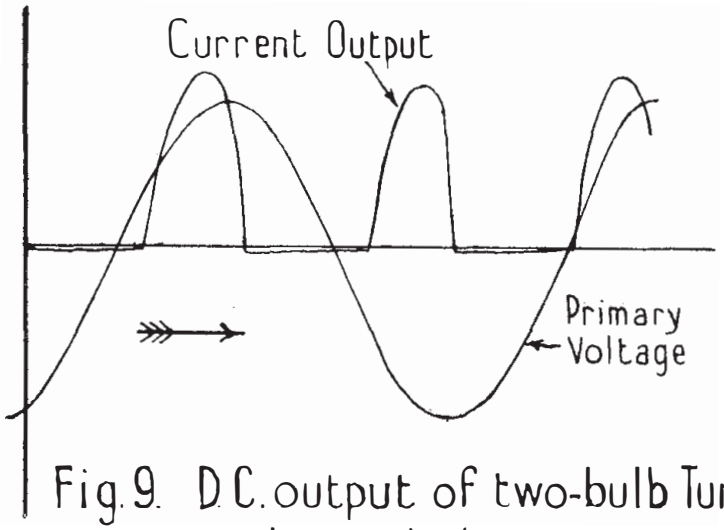


Fig. 9. D.C. output of two-bulb Tungar without choke coil charging battery.

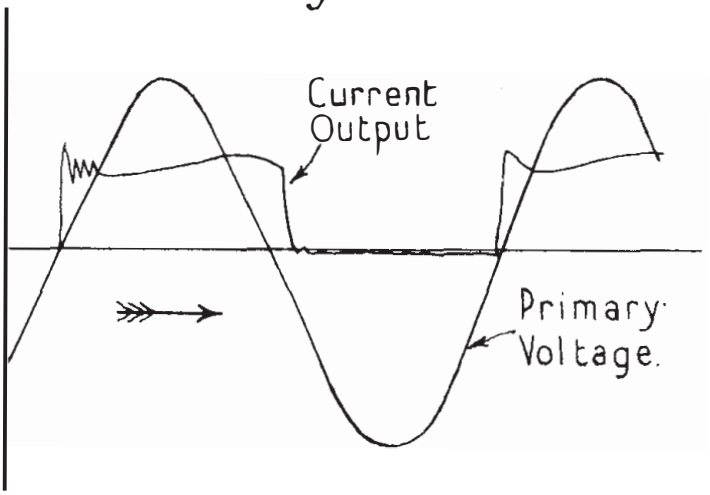


Fig. 10. Output of one bulb of two-bulb Tungar with choke coil.

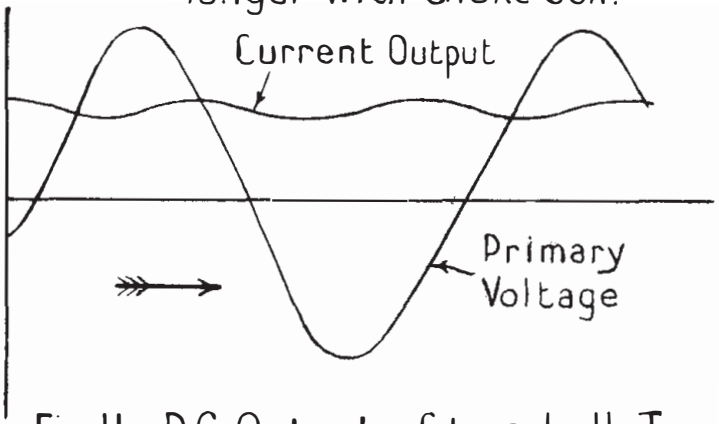


Fig. 11. D.C. Output of two-bulb Tungar with choke coil on D.C. Circuit.

cut-off panel consisting of an ampere-hour meter in the charging circuit which trips a circuit breaker in the primary circuit of the charging machine after a definite output has been given, the plant need not be attended until the next charge is required.

Unlike rotary charging sets the Tungar is almost noiseless in operation and this is a great advantage as in many small installations the power plant is situated in the same room as the switchboard.

The cost of upkeep is, generally speaking, negligible. The only replacements required are bulbs, but provided the rated output currents are not exceeded, these usually have a lengthy life, some bulbs having been known to operate for more than 3000 hours.

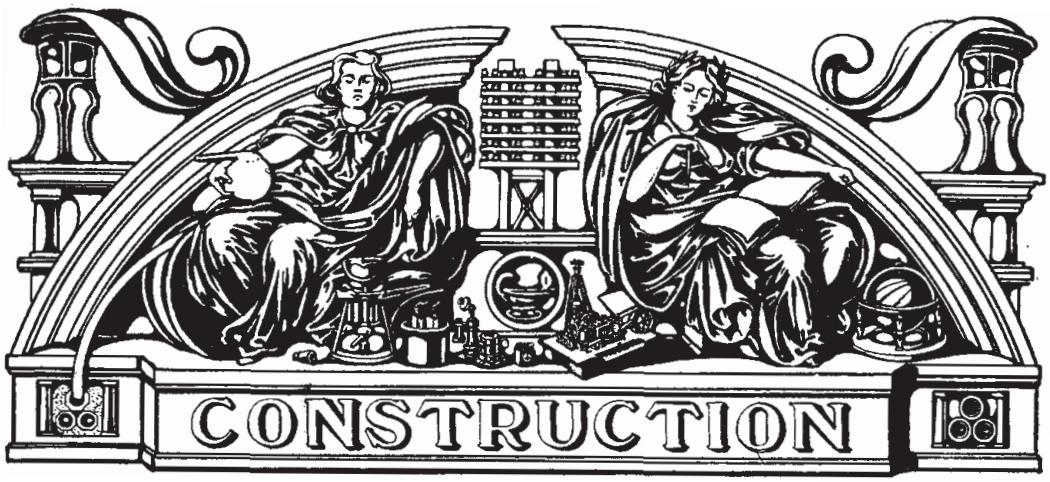
On one or two occasions attention has been called to the fact that this kind of charging machine, especially the single bulb type, produces noise on the exchange during charging operations. This is due to the fact that the current impulses in the charging leads induce current pulses in the adjacent discharge leads. This represents the only disadvantage of the thermionic valve battery charger and the trouble can easily be overcome by using twisted pairs for each battery lead.

The operation of the thermionic valve rectifier is at present being studied mathematically and it is hoped to deal with the Tungar from this point of view in a later issue.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE, IN EACH ENGINEERING DISTRICT AS AT 30TH JUNE, 1926.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
496,248	579	4,171	54,057	479	London	23,454	57,230	1,704,531	70,561
59,976	1,887	21,311	59,750	1,652	S. East	3,823	27,452	121,563	15,961
64,765	4,481	27,410	47,401	2,097	S. West	14,632	6,936	103,996	28,884
51,127	8,322	32,305	44,231	5,015	Eastern	13,919	28,147	67,782	51,152
83,537	8,670	42,017	53,579	3,594	N. Mid.	21,417	40,463	153,093	123,339
61,675	4,872	27,775	60,130	3,805	S. Mid.	12,518	17,817	122,174	83,845
53,676	4,983	28,884	47,244	2,066	S. Wales	5,278	21,196	89,599	68,998
86,611	8,045	24,768	45,263	5,212	N. Wales	12,419	36,586	182,937	55,111
135,993	1,612	16,999	43,923	2,946	S. Lancs.	12,637	75,349	392,565	36,695
81,491	6,018	30,820	42,974	2,909	N. East	9,718	36,125	183,248	27,618
55,133	3,664	24,260	35,517	1,626	N. West	8,629	31,259	118,301	36,277
41,522	2,298	15,719	24,111	2,281	North	4,207	9,802	76,360	54,417
19,101	4,803	6,220	12,271	264	Ireland N.	140	249	35,560	710
56,647	5,454	23,302	34,350	1,295	Scot. East	2,673	8,721	109,270	38,111
77,280	7,443	23,808	40,629	815	Scot. West	12,265	22,520	194,019	33,323
1,424,782	73,131	349,769	645,430	36,056	Totals.	157,729	419,852	3,654,998	725,002
1,396,384	73,228	345,738	640,865	37,033	Figures on 31st March, 1926.	153,621	400,959	3,489,485	676,976



THE ANGLO-DUTCH No. 3 CONTINUOUSLY LOADED SUBMARINE TELEPHONE CABLE.

By A. B. Morice, B.Sc. (Eng.), A.M.I.E.E.

The first submarine telephone cable laid between Aldeburgh (Suffolk, England) and Domburg (Walcheren, Holland) contained four cores insulated with specially prepared gutta percha and was coil-loaded. It was laid in 1922 and a description of it is given in Vol. 16, Part 4, Jan. 1924, of this Journal. The construction of this cable is similar to that of the Anglo-Irish cable which was laid in 1913 between Nevin, North Wales, and Howth, Ireland.

In August 1924, a second Anglo-Dutch telephone cable was laid between the same two places. This cable was the first paper-insulated submarine cable laid between England and the European Continent. It contained four quads of continuously-loaded telephone conductors. A description of it is given in "The Electrician" for September 5th, 1924.

Both of these cables were manufactured by Messrs. Siemens Bros. & Co., Ltd., Woolwich.

In April of this year, a third Anglo-Dutch cable was laid and it is the purpose of this article to give some particulars of its construction and electrical properties.

The Anglo-Dutch No. 3 cable was manufactured by Messrs. Felten & Guilleaume, of Köln-Mülheim, and was laid by the firm's cableship "Neptun," from Domburg to Aldeburgh. The cable consists of four groups of four-wire cores, each spirally wound, together with one central single-conductor core. Each of the 17

conductors is continuously loaded by means of a uniform winding of special silicon iron, and is insulated with three layers of paper.

The conductors of the four-wire groups consist of solid, soft copper of 2.33 mm. (0.0917″) diameter, and are wound with an iron loading wire of 0.2 mm. (0.0079″) diameter; the conductor of the central core consists of 7 copper wires, each 0.81 mm. (0.0319″) diameter and is wound with an iron loading wire of 0.3 mm. (0.0118″) diameter.

The various four-wire groups are distinguished by blue, red, green and white paper wrappings. The distinctive colours for each four-wire group are red, green, white and blue, arranged in that order so that (*a*) red and white and (*b*) blue and green form the diagonal pairs of each quad.

The lengths of lay of the four-wire groups are all different and vary from 350 mm. (13.8″) to 420 mm. (16.5″).

There are two lead sheaths, each 2 mm. (0.079″) thick, and the cable was manufactured in lengths of approximately 30 nauts without a joint in these sheaths.

The armouring consists of 22 steel wires, each 5.8 mm. (0.228″) diameter; the overall diameter of the completed cable is 55 mms. (2.17″), and its weight approximately 19.8 tons per naut.

The length of the cable after laying was 85.736 nauts.

The electrical characteristics obtained from tests will now be given.

D.C. Tests.

From measurements taken of the cable after laying the following results were obtained:—

Average resistance of the 16 cores = 7.308 ohms per naut.
Resistance of centre core = 8.608 ,, ,, ,,

Average insulation resistance of the 17 cores, measured with 100 volts, between each core and the remainder earthed

= 72,900 megohms per naut after 1 min. electrification.
= 109,000 ,, ,, ,, ,, 2 mins. ,,

A.C. Tests.

(*a*) *Transmission Constants.*

The mean A.C. constants of all the pairs and all the phantoms were measured at angular velocities of 5,000, 10,000 and 15,000 radians per second. These tests were made from both ends of the first armoured section, 29.13 nauts in length. The results obtained are given in Table I., in which the measured D.C. resistances have also been included.

TABLE I.

MEAN CONSTANTS OF ALL THE CIRCUITS TESTED FROM BOTH ENDS OF 29.13 NAUTS OF ARMOURED CABLE. TEMP. = 11°C. TESTING CURRENT = 1 M.A.

Circuits tested.	ω Radians per second.	Characteristic Impedance in Vector Ohms.	A.C. Constants per Naut Loop.					D.C. Resistance per Naut Loop in Ohms.
			Attenuation Constant.	Propagation Constant.	Resistance in Ohms.	Inductance in Milli-Henrys.	Capacity in Micro-Farads.	
Pairs	5000	443.0 $\angle 5°11'$	0.01805	0.1843 $\angle 84°23'$	15.58	16.15	0.0828	14.70
	10000	444.4 $\angle 3°56'$	0.02051	0.3661 $\angle 86°48'$	17.30	16.12	0.0828	
	15000	431.8 $\angle 2°47'$	0.02384	0.5493 $\angle 87°29'$	20.00	16.13	0.0828	
Phantoms	5000	185.3 $\angle 5°45'$	0.02074	0.2089 $\angle 84°18'$	7.60	7.82	0.2215	7.35
	10000	188.0 $\angle 4°39'$	0.02290	0.4140 $\angle 86°51'$	8.12	7.69	0.2215	
	15000	180.8 $\angle 1°45'$	0.02653	0.6227 $\angle 87°32'$	9.41	7.75	0.2215	

The variation of the attenuation constant and of the wave length constant with frequency for a selected pair and a selected phantom

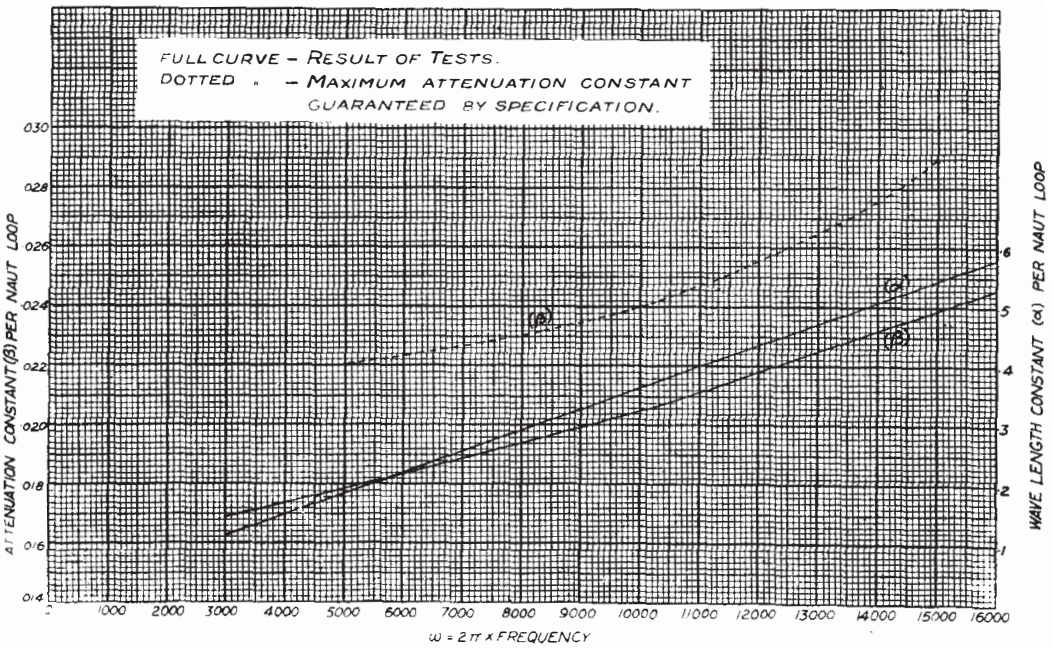

FULL CURVE – RESULT OF TESTS.
DOTTED . – MAXIMUM ATTENUATION CONSTANT GUARANTEED BY SPECIFICATION.
ATTENUATION CONSTANT (β) PER NAUT LOOP
WAVE LENGTH CONSTANT (α) PER NAUT LOOP
ω = 2π x FREQUENCY

FIG. 1.—ANGLO-DUTCH NO. 3 CABLE. ATTENUATION AND WAVE LENGTH CONSTANTS OF PAIR 5 OF FIRST ARMOURED LENGTH OF 29.13 NAUTS.

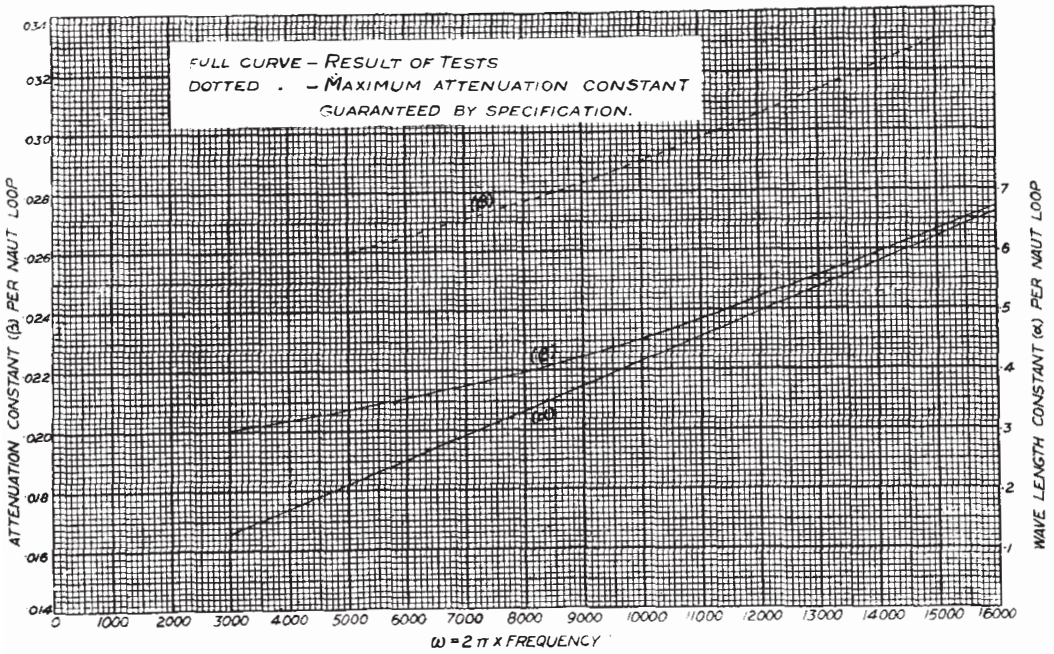

FULL CURVE – RESULT OF TESTS
DOTTED . – MAXIMUM ATTENUATION CONSTANT GUARANTEED BY SPECIFICATION.
ATTENUATION CONSTANT (β) PER NAUT LOOP
WAVE LENGTH CONSTANT (α) PER NAUT LOOP
ω = 2π x FREQUENCY

FIG. 2.—ANGLO-DUTCH NO. 3 CABLE. ATTENUATION AND WAVE LENGTH CONSTANTS OF PHANTOM CIRCUIT OF FIRST ARMOURED LENGTH OF 29.13 NAUTS.

of this same length of cable are shown on Figs. **1** and **2** respectively. It will be observed that the actual attenuation constant

is in each case much less than the figure demanded by the specification. It will also be seen that the difference between β (ω = 12,500) and β (ω = 5000) is 0.0042 and 0.0040 per naut loop for the pair and the phantom respectively.

After laying the cable, the attenuation constant and characteristic impedance of the 8 pairs, the 4 phantoms, and the centre core were measured and the following values obtained:—

TABLE II.

ATTENUATION CONSTANT AND CHARACTERISTIC IMPEDANCE OF THE CIRCUITS OF THE CABLE 85.736 NAUTS LONG.

Circuits.	ω Radians per sec.	Attenuation Constant per Naut Loop.	Characteristic Impedance in Vector Ohms.
Mean of 8 pairs	5000	0.0180	439.0 $\angle 6^\circ 0'$
,, ,, 8 phantoms ...	,,	0.0205	186.2 $\angle 5^\circ 51'$
Centre Core. (Mean of tests from both ends)... ...	,,	0.0227	286.8 $\angle 8^\circ 17'$

From Table II. it is found that the side and phantoms circuits are equivalent to 14.5 and 16.5 miles of standard cable respectively.

The centre core-earth return circuit is equivalent to 18.3 miles of standard cable. A speaking test proved that it formed a very good speaker wire between Aldeburgh and Domburg and, although an earth return circuit, it was free from extraneous noise.

(*b*) *Uniformity of Characteristic Impedance.*

The characteristic impedance of each pair and each phantom was measured over a frequency range from 3,000 to 15,000 radians per second. These tests and the cross-talk tests which follow were all made at Aldeburgh about one month after the cable had been laid.

Fig. **3** shows the variation of the resistance (real part of the characteristic impedance) for the 8 pairs.

Fig. **4** shows the variation of the reactance (imaginary part of the characteristic impedance) for the 8 pairs.

Fig. **5** shows the variation of the resistance and of the reactance for the 4 phantoms.

From Figs. **3** and **5** the results given in Table III. are obtained.

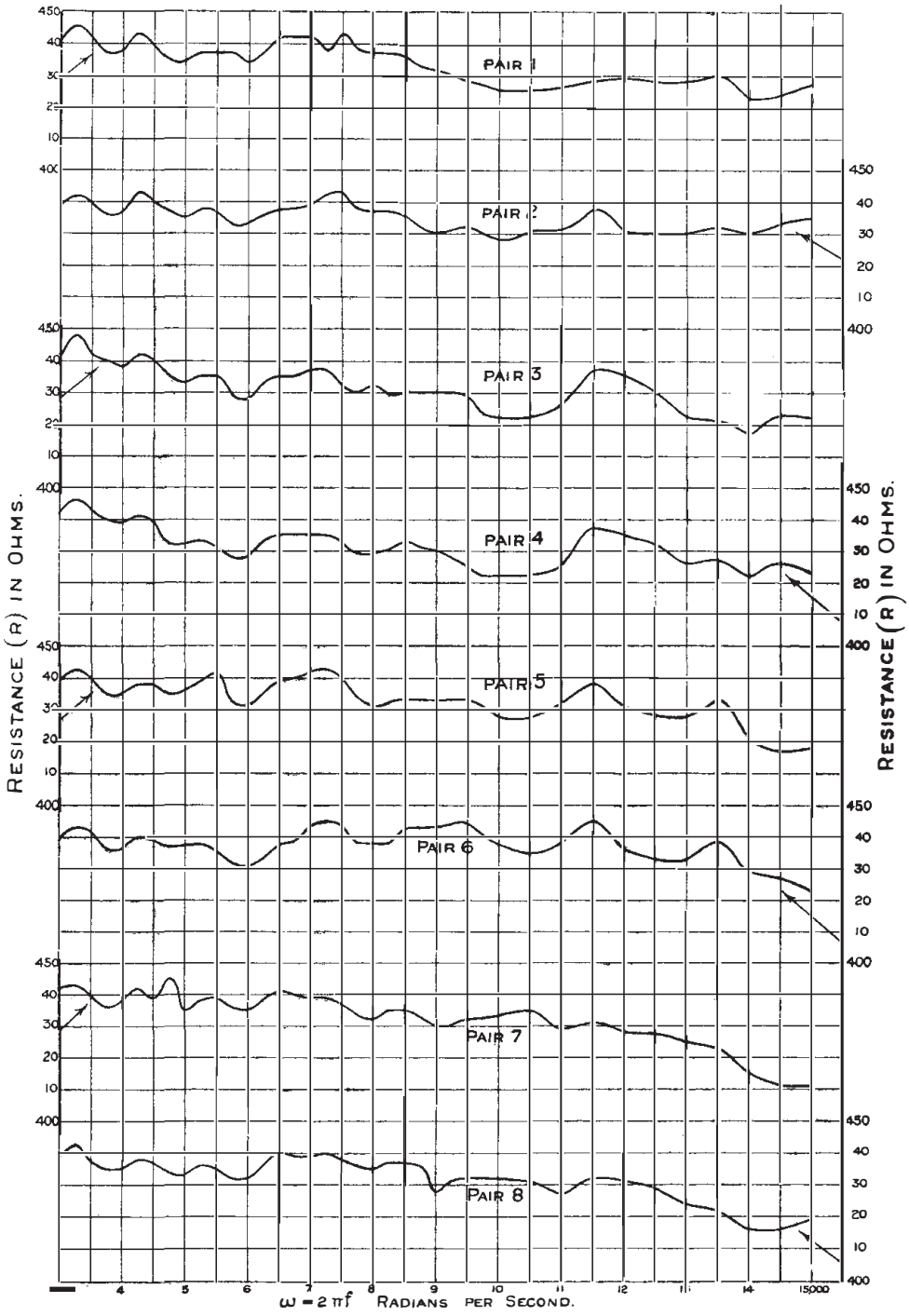


FIG. **3**.—ANGLO-DUTCH NO. 3 CABLE. CHARACTERISTIC IMPEDANCE (REAL PART) OF THE EIGHT PAIRS.

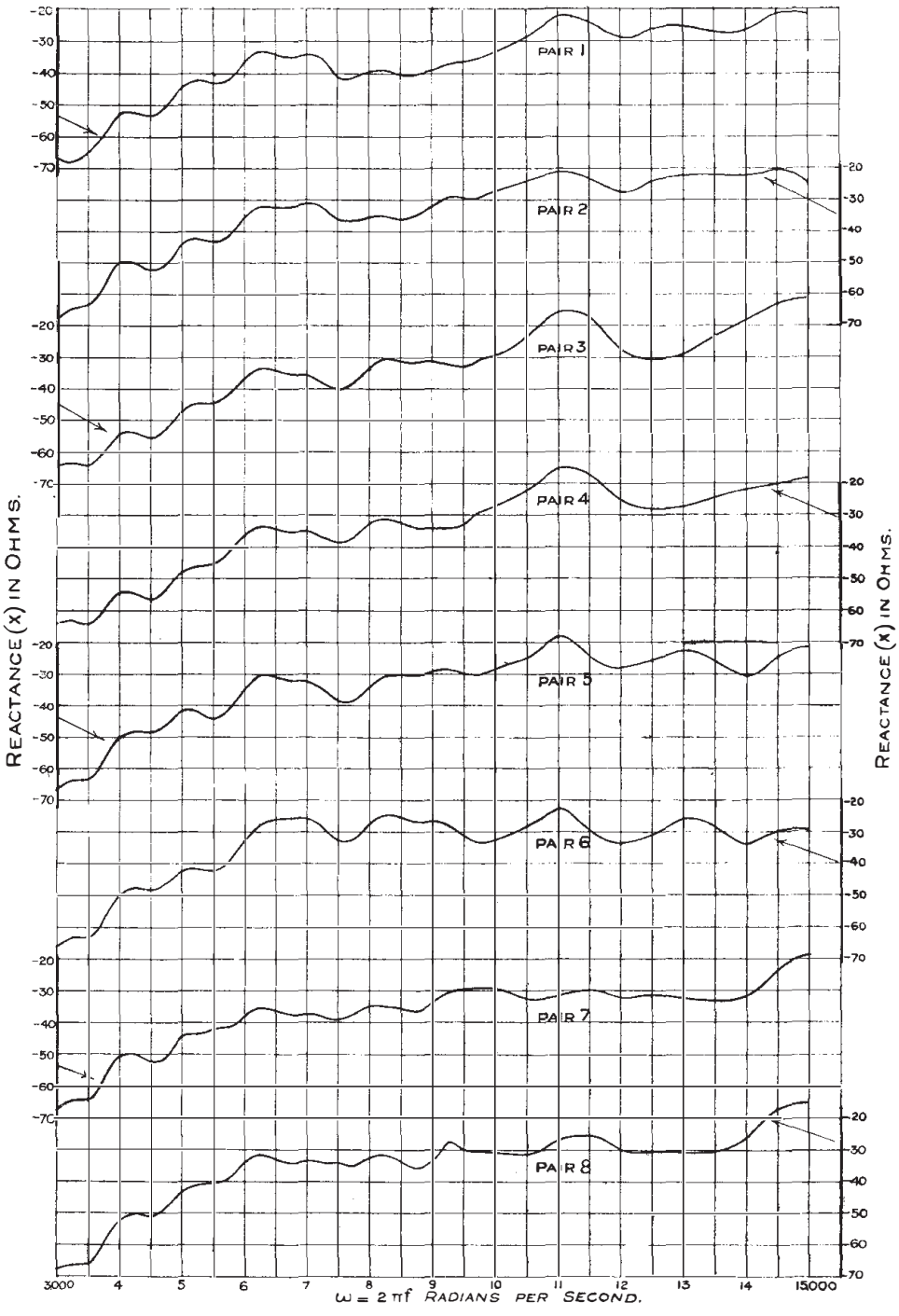


FIG. 4.—ANGLO-DUTCH NO. 3 CABLE. CHARACTERISTIC IMPEDANCE (IMAGINARY PART) OF THE EIGHT PAIRS.

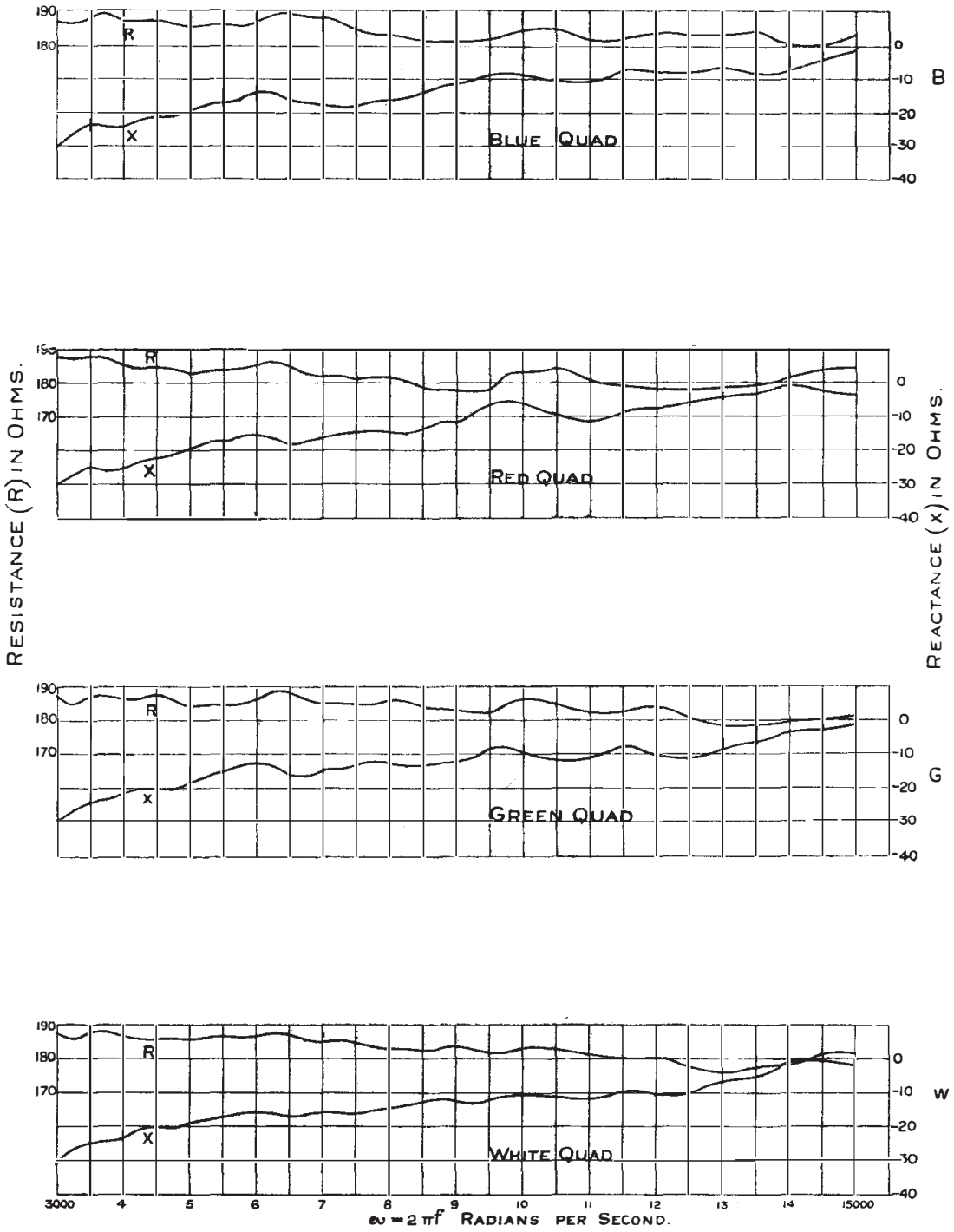


FIG. 5.—ANGLO-DUTCH NO. 3 CABLE. CHARACTERISTIC IMPEDANCE OF THE FOUR PHANTOM CIRCUITS.

TABLE III.

CHARACTERISTIC RESISTANCE WITH FREQUENCY RANGE 3000 TO 12500 RADIANS PER SEC.

Circuit.	Resistance in Ohms.		Variation of Resistance from Mean of Maximum and Minimum values.	
	Maximum.	Minimum.	Ohms.	Percentage.
Pair 1... ...	445.5	425.0	± 10.2	± 2.3
,, 2... ...	443.0	428.0	,, 7.5	,, 1.7
,, 3... ...	448.0	422.0	,, 13.0	,, 3.0
,, 4... ...	446.0	422.0	,, 11.5	,, 2.6
,, 5... ...	442.5	427.5	,, 7.5	,, 1.7
,, 6... ...	445.0	430.5	,, 7.2	,, 1.6
,, 7... ...	445.0	427.5	,, 8.7	,, 2.0
,, 8... ...	442.5	427.0	,, 7.7	,, 1.8
Mean of 8 pairs	—	—	,, 9.2	,, 2.1
Blue Phantom	189.5	181.2	,, 4.1	,, 2.2
Red ,,	187.8	177.5	,, 5.1	,, 2.8
Green ,,	188.9	180.7	,, 4.1	,, 2.2
White ,,	188.0	177.5	,, 5.2	,, 2.9
Mean of 4 Phantoms ...	—	—	,, 4.6	,, 2.5

It will be seen from these figures and the corresponding curves that the characteristic impedances of all the circuits are satisfactorily uniform.

(*c*) *Cross-Talk.*

The cross-talk between the circuits in each four-wire group was measured using (1) alternating current having a frequency range from 2,500 to 15,000 radians per second, and (2) speech.

The measurements on the red and the white quads were made with Siemens and Halske apparatus in βl units, the ends of the cable circuits being suitably terminated. The results obtained with the white quad are shown on Fig. **6**; the five different curves are marked to indicate the test conditions given in the following table:—

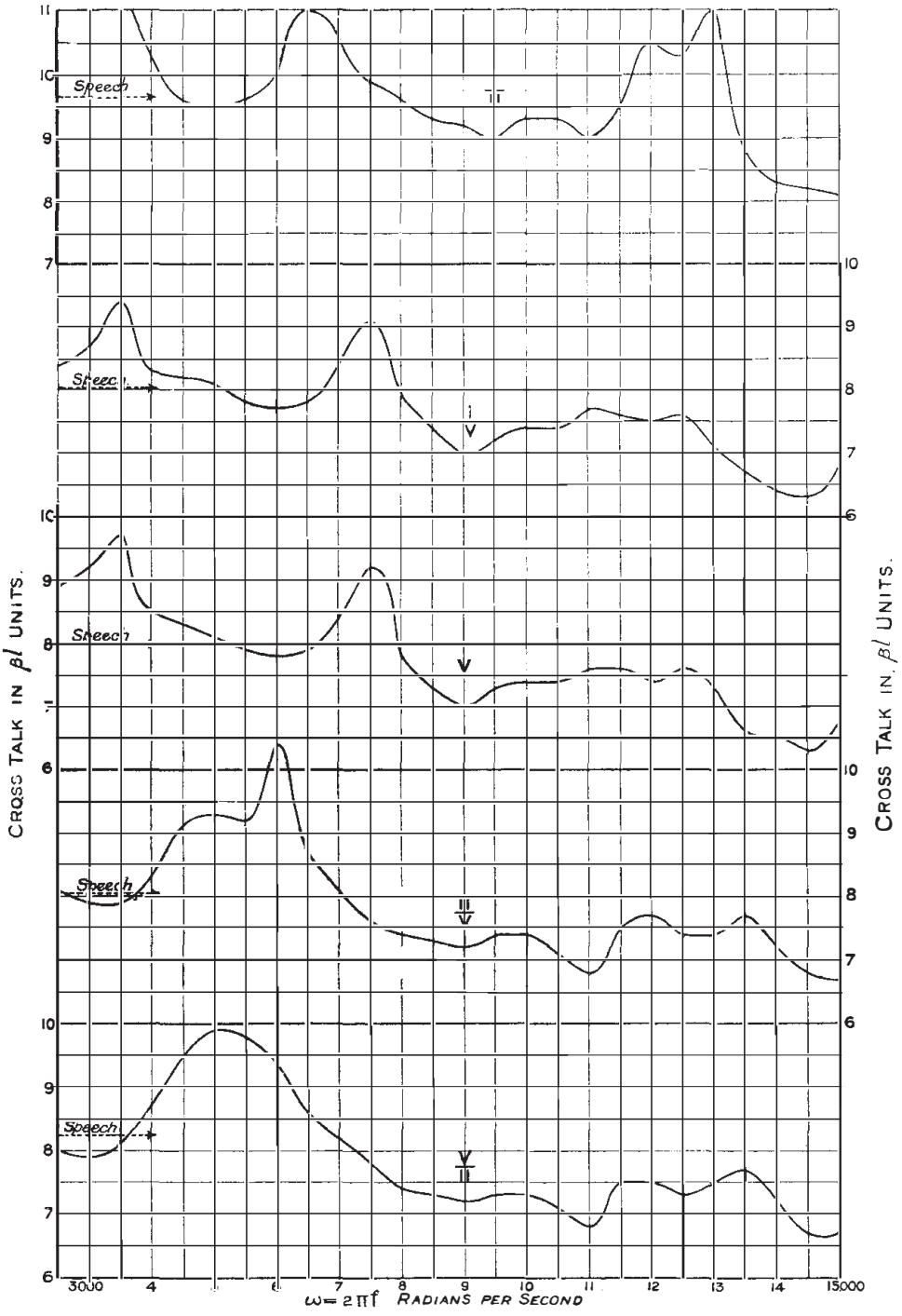


FIG. 6.—ANGLO-DUTCH NO. 3 CABLE. CROSS-TALK BETWEEN THE CIRCUITS OF THE WHITE QUAD.

CROSS-TALK TEST CONDITIONS.

Marking.	Disturbing on	Listening on
I/II	Red—White Pair.	Blue—Green Pair.
I/V	,,	Phantom.
V/I	Phantom.	Red—White Pair.
II/V	Blue—Green Pair.	Phantom.
V/II	Phantom.	Blue—Green Pair.

From the test results of these two quads the figures shown in Table IV. are obtained.

TABLE IV.

CROSS-TALK READINGS IN βl UNITS WITH SIEMENS & HALSKE APPARATUS.

Source of Disturbance.		Red Quad.					White Quad.				
		I/II	I/V	V/I	II/V	V/II	I/II	I/V	V/I	II/V	V/II
Alternating Current Range of ω 2500 to 15000 radians per sec.	Max.	> 11	9.3	10.6	9.8	9.4	> 11	9.4	9.7	10 4	9.9
	Min.	9.4	7.0	6.9	6.1	6.0	8.1	6.3	6.3	6.7	6.7
	Mean	—	8.0	8.0	7.6	7.6	—	7.7	7.8	7.8	7.9
Speech. (Mean of two observers)		> 10	7.8	7.9	7.7	7,6	9.6	8.0	8.0	8.0	8.2

The cross-talk measurements on the blue and the green quads were made with P.O. apparatus, using a Western Electric Cross-Talk Meter connected in parallel, the circuits being terminated with P.O. end sets. The actual readings were in millionths of the disturbing current, but these have been converted to βl units after correction to allow for the effect of the external apparatus and for the difference in impedance between the disturbed and the disturbing circuits. The figures so obtained are given in Table V. which follows:—

TABLE V.

CROSS-TALK READINGS (CORRECTED) IN βl UNITS WITH P.O. APPARATUS.

Source of Disturbance.		Blue Quad.					Green Quad.				
		$\frac{I}{II}$	$\frac{I}{V}$	$\frac{V}{I}$	$\frac{II}{V}$	$\frac{V}{II}$	$\frac{I}{II}$	$\frac{I}{V}$	$\frac{V}{I}$	$\frac{II}{V}$	$\frac{V}{II}$
Alternating Current Range of ω 2500 to 15000 radians per sec.	Max	> 10.3	8.1	8.5	9.3	8.5	10.3	8.5	8.5	9.2	10.3
	Min.	9.0	6.6	6.6	6.6	6.6	8.8	6.8	6.6	6.8	6.7
	Mean	—	7.0	7.1	7.2	7.3	9.5	7.4	7.4	7.6	7.6
Speech. (Mean of two observers)		9.8	7.0	7.1	7.3	7.4	9.7	7.3	7.4	7.7	7.8

The figures in Tables IV. and V. are considered to be satisfactory and it will be noticed that the cross-talk results with speech are, in each of the tables, in close agreement with the mean of the frequency figures.

The cross-talk reading between any circuits in different four-wire groups, measured with a W.E. Cross-Talk Meter, was never less than 9.5 βl units and was usually considerably higher.

A very large number of tests was made on this cable, but it

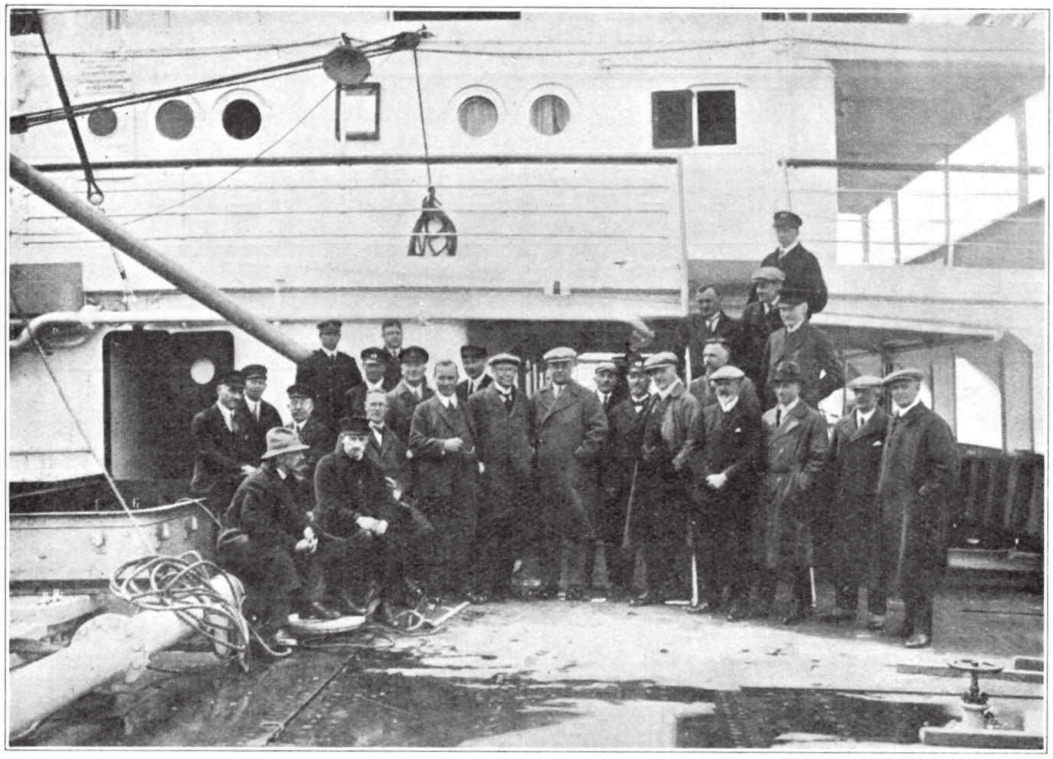
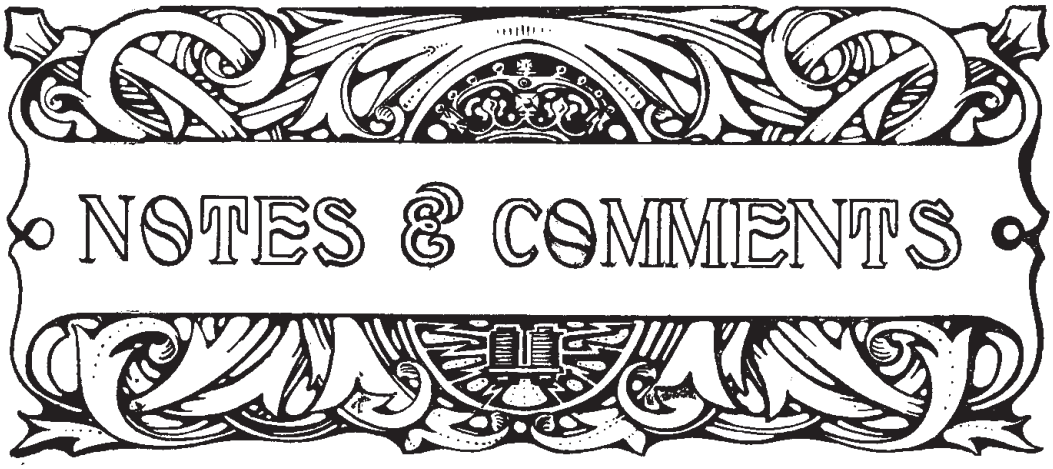


FIG. 7.—AN INTERESTING GROUP ON BOARD THE "NEPTUN."
(From a photo supplied by Messrs. W. F. Dennis & Co.).

would be impossible to include them all in an article of moderate length. It is thought, however, that the representative figures which have been given will suffice to convey an accurate idea of the characteristics of the cable from the telephone point of view.

In conclusion, an interesting photograph is given on page 282, which was kindly supplied by Messrs. W. F. Dennis & Co., 70, Queen Victoria Street, E.C.4, who represent Messrs. Felten & Guilleaume in this country. This photograph was taken on board the cable ship during the laying operations and shows the firm's representatives, together with those of the British, Dutch and German Administrations. See Fig. 7.



NOTES AND COMMENTS.

LONDON has now reached its half million telephones, and although our empire metropolis is still very far behind New York we think there is ground for self-congratulation. Englishmen were a long time in acquiring the telephone habit and even now in private dwellings a telephone is considered more of the nature of a luxury than a necessity. However, the habit will grow and judging from the development during the post war years—which even the most cheerful among us could scarcely call prosperous years—we should see the full million in much less than ten years' time. The five hundred thousandth instrument was handed over to the Chairman of the Press Gallery Committee in the Mother of Parliaments by the Controller of the London Telephone Service on the 16th July.

The coming of the Automatic will be brought under the eyes of London subscribers in the October issue of the Directory, which will be printed with the first three letters of the exchanges in capitals to impress the users with the method of operating the dials when they are supplied with them.

CHARLES EZRA SCRIBNER.—With great regret we have to record the death, on June 25th, of Mr. C. E. Scribner, whose name is familiar to all connected with telephony, and who was personally known to many on this side of the Atlantic. Mr. Scribner was a

schoolboy experimenter in telegraphy, and devised a relay which he submitted to the Western Electric Co. for manufacture or development. This led to his employment by that company, and he was engaged on the maintenance of some special telegraphic instruments when Bell's telephone was introduced. He has related how his company engaged in experiments with the new instrument, which, in telegraphic parlance, was called "the speaker." It was to "the speaker" and its developments that Mr. Scribner's life work was thenceforward devoted. The British patent specification for the multiple switchboard was issued to him in November, 1879, and it has been sometimes assumed that he was the sole inventor of the multiple principle. He was the inventor of the first test system put in operation, but not of all the systems described in that patent. In switchboard development, however, Scribner's name stands pre-eminent. Patents granted to him were very numerous, but as chief engineer of the Western Electric Co. it fell to him to determine the new lines upon which ever-growing requirements should be met. A close student of every phase of telephone operating, he promptly realised new conditions, and set his mind to their provision on lines of economic operating efficiency. His outlook was broad and his advice always governed by the needs of the service. His influence in Europe was considerable and by all those who came in contact with him his loss will be deplored. Mr. Scribner retired from active work some years ago, and it was when on his farm in Vermont—a favourite spot with him even when in active work—that an attack of apoplexy caused his sudden death.—[*Electrical Review*.]

Another well-known man in the States has passed away in the person of John B. Taltavall, publisher of the *Telegraph and Telephone Age*. He was an Englishman, born in North Shields 69 years ago, but went across to the other side at an early age and for the whole of his life was associated with the telegraph business.

We draw our readers' attention to the Montefiore Triennial Prize Competition which falls due again next year. The prize, which has a value of the accumulated interest of a capital of 150,000 francs invested in Belgian 3% Rentes, is awarded to the writer of the best original work on scientific advancement and the technical application of electricity throughout the world. The MS., which must be printed or typed in French or English, should be sent to M. le Secrétaire-Archiviste de la Fondation George

Montefiore, àl'hotel de l'Association, rue Saint Gilles, 31, Liége (Belique), not later than the 30th April, 1927, and should bear plainly at the top of the text the words " Travail soumis au concours de la Fondation George Montefiore, session de 1823-1926." The advice has been issued by Le Secrétaire Général, M. L. Calmeau, at the above address, who no doubt will furnish full information on application.

BRITISH AUTOMATIC TELEPHONE SYSTEM FOR CZECHO-SLOVAKIA.

" Relay " System for Gross-Ostrau and other towns.—The State Telephone Department has decided to convert the manually operated system in the large Moravian industrial town of Mayrish-Ostrau to automatic working. For this conversion the Relay Automatic System of Marconi House has been selected.

According to the scheme already prepared there will be a central exchange of initially 2,500 lines, which will later be extended to 7,000 lines and which will be capable of further extension to 10,000 lines.

In addition to the main exchange at Mayrish-Ostrau six local exchanges will be erected, one for 200 lines in Witkowitz and others in Marienberg, Radvanitz, Hohenstadt and Kruschen and Schonbrunn.

Mr. C. C. Roe, the Publicity Manager of the Relay Automatic Telephone Co., Ltd., of Marconi House, has been appointed Publicity Manager of the Sterling Telephone & Electric Co., Ltd., of Dagenham, Essex. Mr. Roe will continue as Publicity Manager of the " Relay " Company.

Mr. G. A. Saunders, for many years with the British L.M. Ericsson Company and latterly one of the Superintendents at their Beeston Factory, has accepted an appointment as Production Manager at the Dagenham Works of the Sterling Telephone & Electric Co., Ltd., and takes up his new duties on July 5th.

The Sterling Telephone & Electric Co., Ltd., of Dagenham, were successful recently in securing from the Australian Commonwealth, an order for Switchboards to a value of £50,000 in addition to substantial export orders for the Argentine, South Africa and elsewhere.

The Doon,
Purley Oaks Road,
Sanderstead,
Surrey.
24th July, 1926.

The Managing Editor,
P.O.E.E. Journal.

Dear Sir,

In your July issue there is an article entitled "Simplex working on Fast Speed Repeaters." An arrangement very similar to that given by Mr. Lack in this article was adopted in India some 7 or 8 years ago on all D.C. Simplex and D.C. Simplex-Duplex repeaters. In the Indian arrangement in place of two Auto (Neutral) Relays a single relay with two separate and distinct windings is used, one winding being connected in the line circuit (as Auto Relay No. 1 in Mr. Lack's diagram) and the other winding being connected in a leak circuit containing a condenser to the tongue of the line relay (as Auto Relay No. 2 in Mr. Lack's diagram); the connections were, of course, such that the condenser impulses in the auxiliary winding assisted the line currents in the line winding.

The two windings were obtained by separating the two sets of coils normally paralleled inside the relay, one set being connected to (U). (D)–U.D., making the resistance of the line coils, 200 plus 200 ohms, and the other set connected in series and joined to two additional terminals, making the auxiliary winding 400 ohms. This arrangement was found most satisfactory.

Yours faithfully,
C. LAWTON,
late Chief Electrician,
Indian Telegraph Dept.

The above communication was submitted to Mr. Lack, who replied as follows:—

"The first arrangement we tried was similar to that described by Mr. Lawton. (We did not, of course, know of Mr. Lawton's arrangement). It was found that in these conditions the relay acted as a transformer and upset the weak incoming signals in the line relay and we therefore adopted the second auto relay.

Another disadvantage is that the self-induction of the auto relay is greater with a single coil than with the two coils in parallel and has therefore a tendency to reduce the speed of working. I don't know the speed of the Indian circuits, but presumably it would be less than that obtained in this country.

Yours,
E.L.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Bedford New	Auto	1450
Blackburn Extension ...	,,	1000
Grimsby Extension ...	,,	920
Hartlepool New	,,	160
Paignton New	,,	296
Sketty Extension	,,	170
Stanningley Extension ...	,,	260
York Extension	,,	330
Aberdeen Extension ...	Manual	1520
Battersea New	,,	5500
Beaconsfield New	,,	660
Liverpool Central Extn....	,,	3920
Putney Extension	,,	1700
Southend 2nd Relief ...	,,	1110
Walworth New	,,	3700
Whitley Bay Extension ...	,,	900
Armitage & Rigby ...	P.A.B.X.	40
Avonbank Co-op. Society..	,,	20
Burberry's Ltd.	,,	60
Camberwell Guardians ...	,,	40
W. H. Cullen. Ltd. ...	,,	30
Dunkelsbuhler, Ltd. ...	,,	40
Failsworth Co-op. Society.	,,	50
Featherstones, Ltd. ...	,,	30
Fisher & Ludlow	,,	40
Gaumont, Ltd.	,,	50
General Accident Corpn....	,,	30
Harrisons, Ltd.	,,	50
Hawkes & Sons	,,	30
Hinshelwood & Co. ...	,,	40
Manifoldia, Ltd.	,,	30
Motherwell Hospital ...	,,	30
Newton Chambers & Co....	,,	100
Pollard & Co.	,,	60
Rudders & Payne	,,	30
Shell-Mex, Ltd., Fulham...	,,	70
Shoreditch Council ...	,,	50
Stelp & Leighton	,,	40
Stewart Thomson & Co....	,,	40
Swan & Edgar	,,	100
Watney Coombe (Mortlake)	,,	40
Ye Mecca, Ltd.	,,	60

Orders have been placed for the following new Exchanges :—

Exchange.	Type.	No. of Lines.
Colwyn Bay	Auto	1220
Halifax	,,	3100
Llandudno	,,	1140
Llandudno Junction ...	,,	140
Monument	,,	10,000

Exchange.	Type.	No. of Lines.
Old Colwyn	,,	500
Penrhynside	,,	180
Sloane	,,	8700
Batley	Manual	800
Belfast Relief	,,	3610
Govan	,,	660
Maryhill	,,	480
Merstham	,,	340
Wallington	,,	2900
Albright & Wilson ...	P.A.B.X.	40
Anchor Cable Co.	,,	60
Beswick Co-op. Society ...	,,	40
Birmingham Theatre Royal	,,	30
Clyde Valley Co.	,,	60
Equitable Trust Co. ...	,,	50
John Gardner	,,	60
E. & R. Garrould, Ltd. ...	,,	50
Gestetner, Ltd.	,,	40
S. Gratrix, Junr.	,,	30
Hampton & Sons	,,	30
Leyland Rubber Co. ...	,,	30
Liverpool Co-op. Society...	,,	60
Producers Distributing Co.	,,	30
Riseley & Sons	,,	30
Rowe Bros.	,,	30
Rylands Bros.	,,	60
Shell Mex, Ltd., Liverpool	,,	30
Watts Watts & Co. ...	,,	70
West Riding Council ...	,,	100
Weymouth Corporation ...	,,	30
Wiggin & Co.	,,	40
J. Wright & Sons ...	,,	30

Orders have been placed for extensions to existing equipments as follows:—

Exchange.	Type.	No. of Lines.
Torquay	Auto	300
Barnet	Manual	760
Birmingham North ...	,,	960
,, South ...	,,	1360
Darlaston	,,	40
Enfield	,,	760
Leeds Trunk	,,	—
Norwich	,,	720

RETIREMENTS.

Two well known officers at headquarters, Mr. F. L. Henley, Staff Engineer in charge of the Test Section, and Mr. E. Lack, Assistant Staff Engineer, Telegraph Section, have retired owing to the operation of the age limit. Both received tokens of the respect in which they were held by their colleagues. We hope to give further particulars in our next issue, together with sketches of their careers.

LONDON DISTRICT NOTES.

DURING the quarter ended June 25th, 1926, the number of exchange lines, internal extensions and external extensions provided and recovered were as follows:—

	Exchange lines.	Internal Extensions.	External Extensions.
Provided ...	9,865	6,054	1,033
Recovered ...	3,460	3,080	522
Net increase ...	6,405	2,974	511

In the January issue of this journal there appeared two plates illustrating a description of a new Kiosk designed by Sir Gilbert Scott.

These handsome iron structures are now making their appearance in all parts of the Metropolis. An outstanding feature is the amount of glass employed in the construction of the Kiosk, giving a maximum of natural lighting, whilst at night the electric light provided throws an opal telephone sign into relief, thereby attracting the attention of the public to the facilities.

The pierced crowns near the dome provide a means of ventilation through a pierced inner ceiling.

The door itself is of teak and the whole structure, with base, is about 9 ft. in height.

Those already completed have a pleasing external claret-coloured effect, but a definite decision as to the final finish has yet to be reached.

EXTERNAL CONSTRUCTION.

Mileage Statistics.

During the three months ended 30th June, 1926, the following changes have occurred:—

Telegraphs.—A net decrease in open wire of 20 miles and a net increase in underground of 101 miles.

Telephones (Exchange).—A net decrease in open wire (including aerial cable) of 413 miles and a net increase in underground of 46,426 miles.

Telephones (Trunk).—A net increase in underground of 1,658 miles.

Pole Line.—A net increase of 90 miles, the total to date being 5,452 miles.

Pipe Line.—A net increase of 241 miles, the total to date being 6,786 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	24,847
Telephones (Exchange)	1,759,375
Telephones (Trunks)	62,656
Spares	71,040

INTERNAL CONSTRUCTION.

New Exchanges.—A new C.B. 10 Exchange installed by Messrs. Siemens Bros. at Popesgrove (Twickenham) was opened on September 11th. The initial capacity is 1,360 lines.

New Exchanges at Rodney (Walworth) and Battersea will be ready for opening during the ensuing quarter.

G.P.O. South.—Forty ticket tubes from the Trunk Exchange to the Annexe have been provided. These tubes, which are of a special type to carry the Trunk record tickets without the aid of a carrier, run from a distribution table in the main Trunk Exchange to alternate positions in the Annexe.

MR. WILLIAM PENNINGTON.

The London Engineering District recently suffered a regrettable and irreparable loss when Mr. William Pennington, Assistant Superintending Engineer, passed away on August 4th, in his 53rd year.

He entered the Service as a Telegraphist at Belfast in 1889, and was transferred to the Engineering Department in 1895 as a Junior Clerk, subsequently passing through the Engineering grades to Executive Engineer, and quite recently to Assistant Superintending Engineer. Some weeks before his decease, Mr. Pennington was absent on sick leave through digestive trouble. This proved somewhat serious, but, thanks to the nursing of a devoted wife and his own will power, he pulled through and returned to duty. The resumption was, however, temporary, for after a few weeks duty complications ensued and medical advice

had again to be sought during the August Bank Holiday period. An operation was later deemed necessary, but Mr. Pennington did not recover.

Mr. Pennington was responsible for the carrying out of several large and important works for the Department during his service as Engineer. He took a prominent part in the erection of the Fishguard Wireless Station, in which he took the keenest interest. During the War period he laid and repaired many submarine cables in connection with the defences of Milford Haven and Pembroke Dockyard, and was held in high esteem by the Naval and Military Authorities for his services.

Not only has the Department lost a most efficient and capable officer, but the Staff in all its ranks has lost a very sincere and helpful friend. " Pen's " personality was a charming one. He was a raconteur of the first order, had a ready flow of sympathy, and was always full of cheery optimism. He was scrupulously fair in his judgments, which were arrived at surely and quickly. To any of the Staff who wished for instruction and guidance Mr. Pennington possessed that rare quality of giving each one " individual " consideration. He had an excellent memory. His wide provincial experience in Ireland and South Wales was a valuable asset on transfer to London to take charge of the City External Section, where his zeal and administrative qualities soon began to take effect.

H.C.S.

FEDERATED MALAY STATES.

ANNUAL REPORT, 1925. POSTS AND TELEGRAPHS.

THE annual report shows a decided increase in business by the Department over the preceding year in spite of floods and landslides which occurred on an unprecedented scale in various parts of the country. The following extracts from the report may prove of interest :—

Correspondence.—The estimated number of letters, postcards, packets and parcels posted and delivered during the year was 26,755,028, an increase of 1,626,554 on the figures for 1924. The increase is shared by all classes of correspondence and are the highest on record in each class.

Registered Articles.—The number of registered articles posted was 484,323 and 452,308 were delivered—increases of 27,659 and 41,515, respectively, over the 1924 totals. These were actual not estimated figures and the total posted and delivered exceeded the record of any previous year by 69,174. There has again been no

case in which it has been necessary to pay compensation from public funds for the loss of a registered article.

Parcels.—The parcels posted numbered 72,695 and those delivered 150,878, increases of 4,168 and 11,461 respectively.

It is regretted that the British postal authorities have been unable to see their way to establish a weekly instead of a fortnightly parcel despatch in Malaya. Such an improvement it is felt would be greatly appreciated by the public of this country and further representations are being addressed to London.

Cash-on-Delivery.—Seven thousand four hundred and fifty-nine packets bearing trade charges to the value of $71,807 were posted, an increase of 697 in number and $6,333 in value as compared with the 1924 figures. The packets delivered numbered 31,963 and bore trade charges to the value of $533,915, showing an increase of 8,147 in number and $148,645 in value over those delivered in 1924.

Telegraphs. — During the year 413,512 telegrams were despatched and 451,518 were delivered, increases of 58,614 and 161,964 respectively. The revenue derived from telegrams was $342,017 of which $212,153 is included in the stamp sales shown in Appendix XII. The revenue shows an increase of $31,380 as compared with 1924. The value of telegrams sent free of charge for other Government departments was $43,971, a decrease of $2,632.

The question of the introduction of high-speed apparatus has been engaging the attention of the department more particularly with a view to dealing with traffic during and after breakdown of the main lines. The general opinion, taking into consideration the traffic loads, the general state of the lines, climatic conditions and available engineering maintenance staff, seems to favour Wheatstone and action is being taken accordingly.

Telephones.—The number of subscribers to the telephone exchange on the 31st December was 2,827, an increase of 391 during the year. In addition there were 1,401 extension lines, extension bells and private circuits maintained by the department as compared with 1,249 in 1924. The increases have been nearly as great as in any two previous years.

The revenue derived from telephones was $696,782, an increase of $136,426 or 24 per cent. over 1924. The trunk revenue amounted to $212,844, 92 and 41 per cent. higher than the 1923 and 1924 figures respectively.

Engineering.—On 31st December there were 2,561 miles of telegraph and telephone lines and 18,492 miles of overhead wire in the Federated Malay States of which 15,127 miles were telephone

wires. In addition there were 62 miles of underground cables containing 5,959 miles of wire single line. These figures do not include the poles and wires maintained by the Railway Department for their own use. The Posts and Telegraphs Department also owns and maintains 122 miles of line and 422 miles of wire in Johore. It also maintained in addition to its own lines 1½ miles of pole line for Kedah and 327 miles of wire for Johore.

Preliminary investigations continued throughout the year with a view to furnishing data necessary to enable the Consulting Engineers to advise upon the Malayan Trunk Telephone (Cable) Scheme. The completion of a comprehensive trunking scheme for Malaya is becoming a matter of urgency and a vote of $1,000,000, as part of an estimated total cost of $4,500,000, has been entered in the budget for 1926. The data collected have been sent to the Crown Agents with a request that the advice of the Consulting Engineers be sought and that firm estimates of cost be furnished. The Telegraph Engineer is now in England and will be in close touch with the Consulting Engineers and the Crown Agents while the matter is under their consideration.

There seems to be a misapprehension in the public mind in regard to this scheme. It is not merely a matter of connecting Singapore and Penang by telephone—that is only an incident in the scheme which is designed primarily to meet the immediate and future requirements of the Federated Malay States where the demand for trunk service is rapidly outrunning the capacity of the existing system. The scheme will give nearly all telephone subscribers in Malaya reciprocal telephonic facilities. It is moreover hoped that it will be possible to incorporate several telegraph channels in the cable and thereby to increase the reliability and efficiency as well as the capacity of the telegraph system.

One of the greatest needs of the Engineering Branch is a technically trained Asiatic staff. The arrival of an additional Assistant Telegraph Engineer at the end of 1924, appointed specially for instructional purposes, enabled a regular and systematic course to be instituted. Progress was slow, due mainly to the inadequacy of the mathematical knowledge of the students which necessitated a course of mathematics being given as a preliminary to the technical course. The students are keen, however, and the results to date justify the expectation that within a few years the classes will provide the department with a well-trained Asiatic engineering staff.

The only means of entering the better grades of the Engineering Branch will in future be through the technical classes and the qualifying examinations. Apprentices and probationers were appointed in accordance with the scheme for technical subordinates,

preference being given to Malays, the natives of this country, and they are now in training. The department has gladly undertaken the training of Malay youths from Johore and Kedah for the engineering service of those States.

Wireless.—The issue of temporary licences for the use of wireless receiving apparatus was commenced in April and twenty-eight such licences were applied for and issued.

The opening of the new British wireless station near Rugby enabled the British Government to broadcast news throughout the world for free reception by anyone who possessed a suitable receiving set and a knowledge of Morse and the experiments showed that the messages could be fairly reliably picked up by the Penaga Wireless Station. Regular transmissions of news started on 1st January, 1926. Negotiations have since been concluded with several Malayan newspapers whereby the messages are re-transmitted from Penaga by land lines and delivered to them on payment of a small monthly fee. It is understood that the additional news so received has been very acceptable both to the press and to the newspapers reading public.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

LOCAL CENTRE NOTES.

SOUTH LANCASHIRE CENTRE.

The Programme for the second half of the 1925/26 Session included a lecture on "Wireless," by Mr. E. H. Shaughnessy, O.B.E., M.I.E.E.; a paper on "Staff Matters; a General Review," by Mr. G. H. Green; and a paper entitled "Notes on Cabling work and Labour Saving Tools," by Mr. R. C. Balcombe. Good attendances and interest were maintained through the Session.

The lecture on Wireless was of a special interest and importance, and the opportunity was taken, in accordance with the practice of the last few years, to invite the members of the Local Centre of the I.E.E. A large hall was rented for the occasion, and there was a splendid response to the invitation resulting in an attendance of approximately 600.

The lecturer described in some detail, and in his characteristically telling manner, the outstanding features of the Rugby Station. Great interest was aroused and the magnitude of

1. Hunt, R. W.
2. Bentley, F. E.
3. Joscelyne, S. J.
4. Wilcoxon, F. J.
5. Shaw, V. C. H.
6. Ellinson, F.
7. Dunkerley, H. W.
8. Massey, E.
9. Sanderson, E. R.
10. Hibbert, J.
11. Carron, J. R.
12. Ashworth, J.
13. Heaton, A.
14. Gibson, W.
15. Halsall, T. G.
16. McIlwreith, J. W.
17. Shoults, G. M.
18. Warburton, T. E.
19. Partington, J.
20. Lockton, C. P.
21. Downward, F.
22. Jones, J. W.
23. Edwards, E. R.
24. Wilson, C. C.
25. Williams, J. P.
26. Thompson, J. W.
27. Standring, W. W.
28. Barratt, C.
29. Buchanan, J. R.
30. Cross, W. H.
31. Spargo, E.
32. Ball, W.
33. Austin, T. W.
34. Payne, C. F.
35. Cox, C. R.
36. Vernon, R. J.
37. Mercer, H.
38. Harrison, J.
39. Michaelson, F.
40. Goodall, R.
41. Minta, T. A.
42. Gange, A.
43. Partington, B. G.
44. Tansley, R.
45. Batho, G.
46. Dunning, F. T.
47. Williams, C.
48. Potter, W.
49. Hale, F.
50. Wood, W. T.
51. Chase, S. H.
52. Pearson, S. J.
53. Jackson, S.
54. Law, J.
55. Kemp, A.
56. Heathcote, A.
57. Impey, A. B.
58. Jackson, A. G.
59. Wood, W.
60. Storey, C. W.
61. Graham, R. B.
62. Balcombe, F. G.
63. Baxter, F.
64. Wilson, W.
65. Jackson, J. T. H.
66. Bagshaw, H. M.
67. Crossley, W. C.
68. Rowlands, W.
69. Cleaver, J.
70. Cooper, J. O.
71. Capt. Cowburn.
72. Barnard, A. S.
73. Wildgoose, G. H. A.
74. Stevenson, G.
75. Herbert, T. E.
76. McKinnon, E. C.
77. Fletcher, J. F.
78. Dean, H.
79. McCormack, W.
80. Morgan, C. E.
81. White, A. E.
82. Matthews, T. E.
83. Pinkham, W. W.
84. Turley, T. G.
85. Hepplestone, H.
86. Hignett, A. A.
87. Blacow, W. G.
88. Whittaker, W. N.
89. Critcher, W. T.
90. Wainwright, S. W.
91. Lown, S. J.
92. Meldrum, F. A.
93. Turner, H. M.

SOUTH LANCS. CENTRE AT THE CHLORIDE WORKS, CLIFTON.

numerous items of plant installed as well as the complexity of the problems involved came as a surprise to many in the audience.

In the afternoon prior to the meeting, which was held on the 16th February, the members of this Centre visited the works of the Chloride Electrical Storage Company at Clifton Junction. Their visit to the largest accumulator works in the Empire proved most instructive and pleasant, largely because of the truly admirable arrangements made by the Directors for the convenience and comfort of the visitors. Small groups were formed and visited every portion of the works under the guidance of the Company's officials. These gentlemen had evidently been very carefully selected, since the questions raised by our members during the inspection were answered with promptitude and accuracy. To achieve this result the Company provided no less than 14 guides, 4 control officers, and 6 stewards.

The routes taken by the parties never clashed, nor was there a single hitch or wait, and this speaks volumes for the care with which the arrangements had been organised. One little point of detail may be mentioned. Each machine and each process was clearly and distinctly labelled so that even without the guides professional visitors would have been enabled to get quite a good idea of the manufacture of a secondary cell. Everyone was very much struck with the arrangements made to avoid injury to the workers from lead poisoning and it was gathered that in practice such cases were rare. The final exhibit of the standard plates for Post Office cells was interesting and should mark the passing of the day when many differently sized plates are used for approximately the same A.H. capacity.

After the conclusion of the inspection a very welcome light tea was served in the canteen, and a photograph of the party was taken. Mr. Herbert took the opportunity to express our thanks to the Directorate for the admirable arrangements made for our convenience and suggested that after seeing the care bestowed upon the manufacture of the cells it should be appreciated that equal care in their maintenance was clearly called for. Mr. Stevenson suitably responded and, as it transpired, this was the last duty he ever performed for his Company, for we were all shocked to learn of his death only a few days later.

The photograph of the group, with a key, is given on p. 296.

BOOK REVIEWS.

"La Telephonie Automatique." By H. Milon, Engineer-in-Chief of Posts & Telegraphs, France. Published by Ganthier-Villars & Co., Paris.

In the preface of the second edition of this work, M. Milon describes the difficulties that face an author of a treatise on Automatic Telephony. He says:—

> "A complete description of all the existing systems of automatic telephony would provide material for many large volumes. I have, therefore, had to limit myself to describing the essential characteristics of the various systems, to separate out the leading ideas which were present at their conception, and to enter into circuit details only of those systems which are actually in use or under construction in France. Beside this, it is certain that most of these systems have not yet reached their final form; if ever the expression 'final form' can apply to these mechanisms which are almost comparable to living organisms in their flexibility and in the ever-growing combinations which can be obtained, and like them are in a permanent state of evolution. It would, therefore, be useless to attempt to describe the minor details as they exist to-day for they will certainly be different to-morrow."

In spite of these difficulties, M. Milon is to be congratulated on his successful attempt to compress into one volume so much information on the chief systems and at the same time finding room for a chapter on Traffic Calculations and for another on Present and Future Developments.

Although it is perhaps a little unfair to pick out certain parts on which to lay particular stress, one naturally turns first to the description of Strowger systems and, secondly, to the chapter dealing with the fascinating question of the application of automatic telephony to large areas.

It is somewhat unfortunate that the consideration of Strowger switches should commence with a description of plunger line switches and of selectors fitted with side switches, but the author probably considers that in a treatise of this kind some attention must be given to earlier systems.

By way of compensation a chapter is devoted to the latest forms of Strowger equipment. This contains several very interesting circuits which, it is believed, have not been described previously, at any rate outside patent specifications, and which are worthy of serious study.

In the description of the Director system, the circuits and the equipment differ considerably from those about to be installed in

London, but this does not detract from the interest of the text, which shows a very good grasp of the principles governing the use of automatic telephony in large cities.

In other chapters the author deals with the Siemens & Halske, the Austrian, Betulander, Relay, Ericsson and the Western Electric systems of full automatic working, as well as the Clement, Siemens & Halske and Western Electric systems of semi-automatic working.

Consisting of 405 pages with 175 diagrams (of which a large percentage are actual photographs) the book is well printed. As is to be expected, a few slight errors were noticed—the most important being that Figs. 17 and 55 are printed upside down.

In conclusion, the book is considered to be a valuable addition to the text-books on Automatic Telephony and it is to regretted that an English translation or an English treatise covering similar ground is not available.

F.I.R.

"The Lead Storage Battery." By H. G. Brown, A.M.I.E.E. (Second Edition). The Locomotive Publishing Company. 5*s*. nett.

The Secondary Cell has never been so widely used as it is to-day, and the enormous developments during the past few years in connection with the introduction of automatic signalling and switching have resulted in a great increase in the numbers and in the dimensions of Secondary Cell installations used for telephone, telegraph and radio services. In consequence, those responsible for the installation and maintenance of such installations have now more need than ever of a convenient and reliable work of reference on the subject. Mr. Brown's book is eminently suitable for all those who must be acquainted with the essential facts regarding the chemical reactions of the lead cell and who wish to obtain sound practical advice on the erection, treatment, testing, and repair of stationary and portable batteries. The author is to be congratulated on having succeeded in compressing so much authentic and practical information into a book of such convenient size.

J.J.M.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Cohen, B. S.	Asst. Staff Engineer, E.-in-C. Office.	Staff Engineer, E.-in-C. Office.	12-9-26
Ridd, P. J.	Executive Engineer, London District.	Asst. Staff Engineer, E.-in-C. Office.	12-9-26
Wilby, E. J.	Executive Engineer, E.-in-C. Office.	Asst. Staff Engineer, E.-in-C. Office.	13-9-26
Wright, A.	Executive Engineer, London District.	Asst. Suptg. Engr., London District.	1-9-26
Sanger, P. M.... ...	Assistant Engineer, London District.	Executive Engineer, London District.	15-6-26
McDonald, C. G. A....	Assistant Engineer, N. Wales District.	Executive Engineer, (In Charge), Oxford Radio Stn.	1-7-26
Morice, A. B.	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	15-6-26
Nancarrow, F. E. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer, (In Charge), Bodmin Radio Beam Station.	15-6-26
Gadsby, G. J.	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	27-7-26
Elston, J. S.	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	13-9-26
Wilson, F.	Chief Inspector, (In charge), Northolt Radio Stn.	Assistant Engineer, (In Charge), Northolt Radio Stn.	4-9-26
Wilson, A.	Chief Inspector, Scot. West District.	Assistant Engineer, Scot. West District.	1-9-26
Irwin, A.	Chief Inspector, E.-in-C. Office.	Assistant Engineer, (In Charge), St. Albans Radio Stn.	13-9-26
Temple, W.	Inspector, E.-in-C. Office.	Chief Inspector, E.-in-C. Office.	16-6-26
Read, A.	Inspector, S. East District.	Chief Inspector, S. East District.	8-5-25
Faithfull, F. E. ...	,,	,,	25-4-26
Smith, A.	Inspector, S. Wales District.	Chief Inspector, S. Wales District.	6-1-26
Smith, J. G.	Inspector, E.-in-C. Office.	Chief Inspector, E.-in-C. Office.	16-6-26
Vause, A. H.	Inspector, London District.	Chief Inspector, London District.	3-9-26
Miller, A.	Inspector, London District.	Chief Inspector, London District.	9-7-26
Petrie, W.	Inspector, Scot. East District.	Chief Inspector, Scot. E. District.	30-4-26
Ward, D. V.	Inspector, South East District.	Chief Inspector, South East District.	9-8-26
Attenborough, F. C....	Inspector, N. Wa. District.	Chief Inspector, N. Wales District.	4-5-26
Hyde, J.	Inspector, N. Mid. District.	Chief Inspector, N. Mid. District.	31-8-26
Manton, C.	Inspector, Met. Power District.	Chief Inspector, Met. Power District.	8-3-25
Prickett, W.	Inspector, E.-in-C. Office.	Chief Inspector, E.-in-C. Office.	16-6-26
Bothwell, A. D. ...	,,	,,	16-6-26
Carter, T.	,,	,,	16-6-26
Little, W. R.	Inspector, London District.	Chief Inspector, London District.	To be fixed later.

PROMOTIONS—(*Continued*).

Name.	Grade.	Promoted to.	Date.
Flanagan, W. J. C. ...	Skilled Workman, Class I., Wireless Station.	Inspector, Wireless Station.	2-7-26
Bradley, V. A. F. ...	S.W.1, N. Mid. District.	Inspector, N. Mid. District.	5-7-25
Woodhouse, W. T. ...	,,	,,	14-8-25
Finch, T. H.	S.W.1, S. Wales District.	Inspector, S. Wales District.	30-5-26
Verney, J. P. S. ...	,,	,,	30-5-26
Linck, H. C. A. ...	,,	,,	12-1-26
Jacobs, G. E. J. ...	,,	,,	8-3-26
Yeats, H. T. F. ...	S.W.1, S. Mid. District.	Inspector, S. Mid. District.	26-4-26
Farr, A. G. K. ...	,,	,,	12-1-26
Reeves, F. C.	,,	,,	12-4-26
Logan, H. D. ...	,,	,,	26-6-26
Henry, J. ...	,,	,,	1-3-26
Forrester, J.	S.W.1, Scot. West District.	Inspector, Scot. West District.	9-7-26
Burnett, H. J. ...	Skilled Workman, Class I., London District.	Inspector, London District.	23-4-26
Wright, T. D. ...	,,	,,	21-5-26
Sheppard, R.	Skilled Workman, Class I., N. Wales District.	Inspector, N. Wales District.	1-3-26
Sands, J. L.	,,	,,	1-3-26
Wylie, F. L.	Telegraphist.	Repeater Officer, Class II., S. Wales District.	10-7-26

RETIREMENTS.

Name	Grade.	District.	Date.
Henley, F. L. ...	Staff Engineer.	E.-in-C. Office.	11-9-26
Lack, E.	Asst. Staff Engineer.	,,	12-9-26
Henshilwood, G. ...	Executive Engineer.	S. East.	17-6-26
Gallagin, J.	2nd Class Engineer.	Northern.	31-7-21
Pope, T.	Chief Inspector.	S. Mid.	6-6-26
Greenwood, E. ...	,,	,,	21-9-26
Conway, J. M. ...	Inspector.	N. West.	13-6-26
Lang, J. W.	,,	S. Lancs.	30-6-26
Dunigan, J. F. ...	,,	Scot. W.	6-6-26
Bowers, J. S. ...	,,	N. West.	23-7-26

DEATHS.

Name.	Grade.	District.	Date.
Pennington, W. ...	Asst. Suptg. Engr.	London.	4-8-26
Everatt, W. C. ...	Assistant Engineer.	N.E.	14-6-26
Price, J. T.	,,	London.	21-6-26
Cole, J. T.	Inspector.	S. West.	23-6-26

STAFF CHANGES.

RESIGNATION.

Name.	Grade	District.	Date.
Sanger, P. M. ...	Executive Engineer.	London.	8-9-26

TRANSFERS.

Name.	Grade.	Transferred.		Date.
		From.	To.	
De Wardt, R. G....	Exec. Engineer	Oxford Radio Station.	Grimsby Radio Station.	13-7-26
Wilson, F. ...	Asst. Supt, (Wireless)	I. of T.'s Department.	Eng. Dept. as Chief Insp	13-7-26
Chapman, F. G....	Asst. Supt. (Wireless)	,,	,,	13-7-26
Semple, L. G. ...	Pro. Asst. Engr.	E.-in-C. Office.	E. District.	13-6-26
Procter, W. S. ...	Pro. Asst. Engr.	,,	N.W. District.	18-7-26
Gibbs, F. J. ...	Inspector	S. Mid.	E.-in-C. Office.	8-8-26
Brown, A. H. ...	,,	,,	,,	25-7-26
Jarvis, J. W. ...	,,	Scot. E.	Egyptian Telephones.	13-11-25
Coxon, J.... ...	Asst. Engr.	E.-in-C. Office.	N. Wales Dist.	18-7-26

CLERICAL ESTABLISHMENT.

PROMOTIONS.

Name.	Grade.	District.	Date.
Lyle, R.	Clerical Officer, South East District.	Higher Clerical Officer, North East District.	11-7-26

RETIREMENTS, ETC.

Name.	Grade.	District.	Date.	Remarks.
Feben, H. M. ...	Exec. Officer	E.-in-C. Office.	17-9-26	Retired.
Watson, E. W. ...	Higher Clerical Officer	Scot. West.	15-8-26	,,
Badger, E. J. C....	Higher Clerical Officer	South Wales.	10-8-26	,,

TRANSFERS.

Name.	Grade.	From.	To	Date
Lean, W. G. ...	Higher Clerical Officer	North East.	Scot. West.	20-6-26
Gain, P. G. W. ...	,,	South East.	South Wales.	22-8-26

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

PROGRAMME, 1926-27.

LONDON CENTRE.

Date.	*Title.*	*To be read by*
1926.		
12 October.	"Trans-Atlantic Telephony" ...	Lt.-Col. A. G. Lee, M.C., B.Sc., M.I.E.E.
9 Nov.	"Phases in Automatic Telephony"	W. Day, M.I.E.E.
14 Dec.	"Economics of Line Plant Provision"	H. Kitchen, M.I.E.E.
1927.		
11 Jan.	"Motor Transport in the Engineering Department"	R. T. Robinson, A.M.I.E.E.
8 Feb.	"Voice Frequency Telegraphs" ...	W. Cruickshank, M.I.E.E.
8 Mar.	*Subject to be arranged.*	J. W. Atkinson, M.I.E.E.
10 May	"Telephone Repeaters: Operation and Maintenance"	J. E. Statters.

EASTERN CENTRE.

1926.		
Oct.	"Telephone Repeaters"	C. J. Jones.
Nov.	"Steam Turbines"	L. G. Semple.
Dec.	"Some Notes on Automatic Telephony"	C. W. Brown, M.I.E.E. (*E.-in-C.O.*).
1927.		
Jan.	"Local Line Plant Economics" ...	H. Kitchen, M.I.E.E. (*E-in-C.O.*).
Feb.	"Traffic Records in Auto-Exchanges"	G. F. O'Dell, B.Sc., A.K.C., M.I.E.E. (*E.-in-C.O.*).
Mar.	*To be arranged.*	T. Cobbe.

NORTHERN CENTRE.

1926.		
1 July	Visit to Cable Laying Work at Holy Island.	
20 Oct.	"Scientific Organisation and the P.O. Engineering Department"... ...	F. G. C. Baldwin, M.I.E.E.
17 Nov.	"The Control of Adivce Note Work"	J. Lane.
15 Dec.	"Wayleaves and relative difficulties"	B. Miller.
1927.		
19 Jan.	"Local Line Plant Economics" ...	H. Kitchen, M.I.E.E. (*E.-in-C.O.*).
16 Feb.	"Local Underground and Open Faults, their detection and clearance"	J. Brown.
16 Mar.	"The West Hartlepool Automatic Exchange and Transfer" ... ... And Visit to West Hartlepool Exchange.	W. Nicholson and J. Parker.

NORTH EASTERN CENTRE.

1926.		
1 Oct.	"Hull Telephone System"	J. T. Tattersall.
9 Nov.	"Local Line Plant Economics" ...	H. Kitchen, M.I.E.E. (*E.-in-C.O.*).
— Dec.	"Preparation of Underground Development Schemes and suggestions *re* Cabling Layout"	G. Bailey.
1927.		
— Jan.	"Engineer-in-Chief's Automatic Telephone Training School. Impressions"	W. V. Ryder.
— Feb.	"Overhead Construction"	J. Shee.
— Mar.	"Works Estimates"	J. E. Suret

PROGRAMME, 1926-27.

NORTH WESTERN CENTRE.

1926.		
11 Oct.	"A comparison of desiccation methods"	E. HOPPER.
2 Nov.	"Local Line Plant Economics" ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
6 Dec.	"Ways and Means in an Engineering Section"	S. UPTON, A.M.I.E.E.
1927.		
11 Jan.	"A Comprehensive View of Automatic Switching"	W. BEATTIE, A.M.I.E.E.
14 Feb.	"More about Amateur Wireless Stations"	H. HORROCKS.
6 Mar.	"Curiosities of Official Literature"	R. A. JONES.
	Visit to Southport New Automatic Exchange. (Date will be announced later.)	

SOUTH LANCASHIRE CENTRE.

1926.		
18 Oct.	"Progress and Development in the P.O. Engineering Department" ...	W. J. MEDLYN, M.I.E.E.
15 Nov.	"Reminiscences"	A. MAGNALL.
6 Dec.	"Local Line Plant Economics" ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
1927.		
17 Jan.	"Motor Transport"	T. KENYON.
7 Feb.	"Problems in Large Underground Construction Works"	J. CLEAVER, A.M.I.E.E.
7 Mar.	"Voice Frequency Telegraphs" ...	W. CRUICKSHANK, M.I.E.E. (*E.-in-C.O.*).
11 Apr.	"Telephone Repeaters — Operation and Maintenance"	J. E. STATTERS (*E.-in-C.O.*).

NORTH MIDLAND CENTRE.

1926.		
4 Oct.	"Derby Repeater Station"	T. S. SKEET.
8 Nov.	"Local Line Plant Economics" ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
6 Dec.	"Private Auto Branch Exchange. Relay Automatic System"... ...	J. HYDE..
1927.		
3 Jan.	"Transmission on low power" ...	C. A. CARPENTER.
	To be followed by a visit to the Nottingham Super-Power station.	
7 Feb.	"Electrolytic Action in Lead Covered Cables"	J. R. MILNES, A.M.I.E.E.
7 Mar.	"Private Automatic Branch Exchange. W.E. Type"	F. H. ROBERTS.

NORTH WALES CENTRE.

1926.		
13 Oct.	"Control of Expenditure by Supervising Officers"	G. H. CARRIER.
10 Nov.	"Birmingham Telephone Repeater Station"	R. P. COLLINS.
	(Meeting at Birmingham.)	
8 Dec.	"Ferro-Concrete Construction" ...	J. B. SALMON.
1927.		
12 Jan.	"Local Line Plant Economics" ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
9 Feb.	"Inspection of Amateur Wireless Stations"	H. B. SOMERVILLE, B.ENG. (*E.-in-C.O.*).
9 Mar.	"Protection of Department's Plant from Power Circuits"	H. W. GREEN.

SOUTH WALES CENTRE.

1926.		
11 Oct.	"Local Line Plant Economics" (Provisional date for this paper.) ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
8 Nov.	"Extension circuit from C.B. Private Branch Exchanges and from C.C. Bell Sets"	W. H. LANE.
13 Dec.	"Trans-Atlantic Telephony" ...	LT.-COL. A. G. LEE, M.C., B.SC., M.I.E.E. (*E.-in-C.O.*).
1927.		
10 Jan.	"Inspectors' Work"	J. H. HAYNES.
14 Feb.	"Repeater Station Working" ...	G. E. J. JACOBS.
14 Mar.	"Phonogram Switches"	H. C. A. LINCK.

SOUTH MIDLAND CENTRE.

1926.		
— Oct.	"The theory of the Electric Current. An Historical Survey"	J. E. TAYLOR, M.I.E.E. (*The Chairman*).
— Nov.	"Local Line Plant Economics" ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
— Dec.	"Economical Construction"... ...	S. D. PENDRY.
1927.		
— Jan.	"Some Notes on Local Arrangements for financing a District"	E. W. DEANE.
— Feb.	"The Training of Inspectors" ...	E. CLIFFORD HARRIS.
— Mar.	(1) "Advice Notes"	S. MOODY.
	(2) "Advice Note Work from an Engineering point of view"	W. L. TAYLOR.
— Apr.	"Power Plant. Acceptance Testing"	P. J. CAMPBELL.

SOUTH WESTERN CENTRE.

1926.		
—	"The Rugby Station"	E. H. SHAUGHNESSY, O.B.E., M.I.E.E. (*E.-in-C.O.*).
—	"The Automatic Relay System" ...	PROF. DAVID ROBERTSON, D.SC., M.I.E.E.
—	"Local Line Plant Economics" ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
1927.		
—	"Traffic Records in Auto Exchanges"	G. F. O'DELL, B.SC., A.K.C., M.I.E.E.
—	*To be arranged.*	(*E.-in-C.O.*).

SCOTLAND EAST CENTRE.

1926.		
— Nov.	"Automatic Trunking Schemes" ...	H. W. DIPPLE, A.M.I.E.E. (*E.-in-C.O.*).
— Dec.	"Reports"	J. D. TAYLOR, M.I.E.E.
—	"Local Line Plant Economics" ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
1927.		
— Feb.	*To be arranged.*	
— Mar.	"Secondary Cell Installations" ...	J. M. COUCH.
— Apr.	*To be arranged.*	

SCOTLAND WEST CENTRE.

1926.		
4 Oct.	"Wireless" popular lecture ...	VINCENT A. M. BULOW (*Brit. Broadcasting Co.*).
1 Nov.	"Main and Local Overhead and Cable Records"	M. McKENZIE.
6 Dec.	"Description of Working 4-wire Trunk Circuits from Glasgow Trunk Ex."	A. ARNOLD.
1927.		
17 Jan.	"Local Line Plant Economics" ...	H. KITCHEN, M.I.E.E. (*E.-in-C.O.*).
7 Mar.	*To be arranged.*	T. HETHERINGTON, A.M.I.E.E.

MEMBERS OF COUNCIL AND OFFICERS FOR THE YEAR 1926-7.

MEMBERS OF COUNCIL.

Chairman—Mr. A. L. DeLattre, Asst. Engineer-in-Chief, G.P.O., E.C.1.

Treasurer—Mr. B. O. Anson, E.-in-C's Automatic Training School, Engineer-in-Chief's Office, G.P.O., E.C.1.
Mr. C. J. Mercer, Engineer-in-Chief's Office, G.P.O., E.C.1.
Mr. E. J. Wilby, do. do. do.
Mr. A. Wright, Sectional Engineer, Denman Street, S.E.
Mr. W. J. Rolfe, do Preston.
Mr. J. H. Bell, c/o Suptg. Engr., Denman Street, S.E.
Mr. C. E. Morgan, c/o Suptg. Engr., Manchester.
Mr. J. D. Boulton, Denman Street, S.E.
Mr. A. S. Carr, c/o Suptg. Engr., H.P.O., Southport.
Mr. E. T. Larner, c/o Suptg. Engr., Denman Street, S.E.
Mr. H. Longley, do. Croydon.
Mr. A. W. Lines, do. Reading.
Mr. H. J. Millett, do. Newcastle.
Mr. R. P. Collins, do. Birmingham.
Mr. C. W. Messenger, P.O.E.D., Centre Internal, 39, Charing Cross Road, W.C.2.

Secretary—Mr. R. V. Hansford, G.P.O., E.C.1.

COMMITTEES OF COUNCIL.

Finance and General Purposes Committee—
Mr. A. L. DeLattre (Chairman).
Mr. B. O. Anson.
Mr. C. W. Messenger.
Mr. E. J. Wilby.
Mr. R. V. Hansford (Secretary).

Board of Editors of Journal—
Mr. B. O. Anson (Chairman of Board).
Mr. W. Cruickshank (Managing Editor).
Mr. J. W. Atkinson.
Mr. H. Longley.

Editing Committee—
Mr. E. J. Ivison (Chairman).
Mr. J. W. Atkinson.
Mr. C. J. Mercer.
Mr. W. L. Hart.
Mr. R. V. Hansford (Secretary).

Selection Committee—
Mr. B. O. Anson.
Mr. J. H. Bell.
Mr. A. Wright (Secretary).

Library Committee—
Mr. J. D. Boulton.
Mr. E. T. Larner.
Mr. E. J. Wilby.
Mr. A. Wright (Chairman).
Mr. J. Smerdon (Librarian & Secretary).

Programmes Committee—
Mr. B. O. Anson.
Mr. C. J. Mercer.
Mr. R. V. Hansford (Secretary).

Librarian—
Mr. J. Smerdon, G.P.O. (Alder House).

Asst. Secretary—
Mr. H. L. Dunster, do. do.

Asst. Editor of Journal—
Mr. J. J. McKichan, do. do.

ESSAY COMPETITION, 1926-27.

The Council has decided to offer FIVE PRIZES of TWO GUINEAS each for the FIVE most meritorious ESSAYS submitted to it by employees of the Engineering Department of the Post Office, below the ranks of Inspector and Draughtsmen Class II., and, in addition, to award a limited number of Certificates of Merit.

Each Competitor may choose any subject relevant to current Telegraph or Telephone practice. It is thought that the list given below of suitable subjects for Essays, though not exhaustive, will prove of assistance to Competitors. The subject need not, however, be chosen from this list, but must be relevant to current Telegraph or Telephone practice :—

Telephone Repeaters.
Telephone Development.
Telephone Fitting.
Cord Circuit Repeaters.
Trunk and Junction Testing.
The Wiring of Large Buildings.
Extension of Large Multiples.
Subscribers' Switchboards.
Telephone Buildings.
Automatic Telephony.
Semi-Automatic Telephony.
Rural Automatic Exchanges.
Automatic Private Branch Exchanges.
Multi Office Automatic Telephony.
Underground Cables.
Precision Testing in Underground Cables.
Cable Drawing.
Cable Balancing.
Overhead Line Construction.
Overhead Line Maintenance.
Aerial Cables.
The Training of Youths.
Primary Batteries.
Secondary Batteries.
Matters for Reform.
Development Studies.
Advice Note Procedure.
Unit Costs.
Store Keeping.
Oscillographs.
Fire Alarm Systems.
Electrical Clocks.
Insulation.
Numbering Machines.
Stamping Machines.
The Loading of Telephone Circuits.
Modern Telephone Practice.
Telephone Line Construction.
A Short History of Telephony.
Telephone Transmission over A.S.P.C. Cables.
The Installation of a New Telephone Exchange Equipment.
Change Over from an Old to a New Exchange Equipment.
Common Battery Manual Telephone System.
Common Battery Signalling Manual Telephone System.
The Telephone System in the British Post Office.
The Elementary Principles of Telephonic Repeaters.
Telephony Considered from a Subscriber's point of View.
A Long Distance Conversation.
The Use of Motor Transport in the Telephone Business.
Routine Testing of Automatic Exchanges.
A Practical Analysis of Characteristic Faults at Automatic Exchanges.
Manual versus Automatic Telephony.
Fault Procedure at Automatic and Manual Exchanges.
The London Trunk Exchange.
The Laying of Pipes and Ducts.
The Construction of a modern Balanced Cable.
Overhead Construction—Precautions to avoid Interference with Working Circuits.
Technical Education in Practice.
Modern Aspects of Electricity and Magnetism.

The Theory of the Accumulator.
The Economy of the Leclanché Cell.
Practical Electrical Units, Sub-Units, etc.
The Ventilation and Heating of Automatic Exchanges and Repeater Stations.
Telegraph Working without Batteries.
Telegraph Printing Apparatus.
Emergency Maintenance.
Long Distance Wireless.
The Thermionic Valve.
Capacity Effects in Telephony—Wired and Wireless.
Carrier Wave Telegraphy and Telephony.

Each Essay must be written on foolscap, one side of the paper only, and must not exceed 5,000 words.

The Essays must reach the Secretary,
The Institution of Post Office Electrical Engineers,
G.P.O. (Alder House), E.C.1.
by the 31st December, 1926.

The Council reserves the right to refrain from awarding the full number of prizes, if in its opinion, the Essays Submitted do not attain a sufficiently high standard.

R. V. HANSFORD,
Secretary.

BOARD OF EDITORS.

B. O. ANSON, M.I.E.E., Chairman.

E. H. SHAUGHNESSY, O.B.E., M.I.E.E., M.I.R.E.
J. W. ATKINSON, M.I.E.E.
Lieut.-Col. A. C. BOOTH, M.I.E.E
H. LONGLEY.

W. CRUICKSHANK, M.I.E.E., Managing Editor.
J. J. MCKICHAN, Assistant Editor, A.M.I.E.E.

COMMUNICATIONS.

All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, Alder House, London, E.C.1.

Binding covers and copies of the Contents for Vol. 3 to 18 are available, and may be obtained from the local agents for 1*s.* 6*d.* and 3*d.* respectively. Subscribers can have their copies of Vol. 18 bound, with index included, at a cost of 3*s.* by sending the JOURNALS to the local agents. Orders should indicate whether the original binding with black lettering, or the later pattern in gold, is required.

The price of the JOURNAL is 1*s.* 6*d.* (1*s.* 9*d.* post free) per copy, or 7*s.* per annum, post free. All back numbers 2*s.* each.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

Officers of Colonial and Foreign Telegraph Administrations who are engaged in Electrical Engineering Works may be admitted as Colonial and Foreign Corresponding Members respectively, after application.

Subscription payable annually in advance on 1st April in each year:

Colonial Members	... ...	£1 0 0
Foreign ,,	... ...	£1 10 0

These sums include Annual Subscription to the Journal of P.O. Electrical Engineers and the supply of all Professional Papers issued during the period covered by subscription.

Forms of application for Colonial and Foreign Membership can be obtained on application to

The Secretary,
Institution of P.O.E. Engineers,
G.P.O., Alder House, E.C.1.

HENLEY

The name above and the Trade Mark below are known to Engineers at home and abroad as symbols of all that is best in the manufacture and installation of

Dry Core Cables.

Henley Cables are good cables. If better cables could be made, it is safe to presume they would be

HENLEY CABLES

W. T. HENLEY'S TELEGRAPH WORKS CO., Ltd.
HOLBORN VIADUCT, LONDON, E.C. 1.

Founded by WILLIAM THOMAS HENLEY about the year 1837.

852

INDEX TO ADVERTISERS.

	PAGE
Automatic Telephone Mfg. Co., Ltd	iii
British L.M. Ericsson Mfg. Co., Ltd.	v
Creed & Co., Ltd.	viii and ix
Henley's, W. T., Telegraph Works Co., Ltd. ...	xi
Johnson & Phillips, Ltd.	xvi
London Electric Wire Co. & Smiths, Ltd.	ii
Peel-Conner Telephone Works, Ltd.	xv
Pitman & Sons, Ltd.	ii
Siemens Bros. & Co., Ltd.	vi and vii
Smith, Frederick, & Co.	xiv
Standard Telephones and Cables, Ltd.	x
Telephony Publishing Corp.	xii
The Electrical Review, Ltd.	iv and xii
Tungstone Accumulator Co., Ltd.	x
Zeva Elektricitats AKT. GES.	xiv

THE ELECTRICAL REVIEW.

To the progressive Post Office Electrical Engineer the "REVIEW" offers the best means of keeping abreast with modern developments, not only in his own section of the industry, but also in every sphere in which electricity is employed both here and abroad.

Price 6d. weekly.

THE ELECTRICAL REVIEW, 4, Ludgate Hill, London, E.C.4.

The Engineering talent

all over the world reads TELEPHONY because it helps them keep abreast of the important developments in the telephone industry.

Telephony
THE AMERICAN TELEPHONE JOURNAL

has been the leading journal in its field for 25 years—a quarter of a century of valued service to its readers. Subscription price (foreign, including postage) $5.00. Issued weekly.

TELEPHONY PUBLISHING CORP.,
608 S. Dearborn St., Chicago, Ill., U.S.A.

THE ONLY ACCUMULATOR IN THE WORLD WITH PLATE-GRIDS MADE OF PURE LEAD

with the Plate Grids Die Cast and Pasted entirely by machinery. Without Wood Separators or Celluloid, eliminating internal resistance and heat which shortens the life of other makes of plates, and creating constant trouble.

TUNGSTONE
Pure Lead Grid
Accumulator

ROBUST Machine-made Plates permit charge and Discharge at Continuous High Rates with Safety. No possibilities of the Plates Buckling or short-circuiting in service. No Fire or Explosion Risks when Charging above Normal Rates. A Tungstone Battery is not fully charged unless the Acid shows fully 1300 Sp.G. Tungstone Robust Machine Made Plates are in best condition when always kept fully charged.

VERY IMPORTANT ADVICE TO MOTORISTS.

Arrange for Car Dynamo output to be permanently increased so that at a car speed of 20 miles per hour the continuous charging rate is as follows, viz.:

40 a.h. Battery minimum charging rate is 8 amps.
50 a.h. „ „ „ „ 10 amps.
75 a.h. „ „ „ „ 15 amps.

Tungstone Machine Made and Pasted Plates are Heavier and Stronger than any other make of Plate, and therefore can be continuously charged at these higher rates than any other make of battery.

Tungstone Plate Grids being made of Pure Lead, and the Paste of Pure Lead Oxides, ensures exceptional storage capacity and quick discharges, therefore provision is made to give continuous, ample and generous power for Self-starting without cranking.
Follow these instructions and you permanently get the full benefits of the originality of Tungstone Design and Manufacture of a Pure Lead Plate and Grid giving exceptional Strength, Storage, Dependability, Reliability, Security, and Safety.

CHARGING HIGH TENSION AT 12-16 VOLTS POTENTIAL.

All H.T. Tungstone Accumulators are fitted with a Patent Equipment whereby each series of 12 Volts can be coupled in parallel so that these H.T. Batteries of whatever voltage can be charged at local Garages and Charging Stations on a 12-16 Volt Low Tension Charging Plant.
Charging Terminals are provided on the front of the Cabinet arranged in two rows, the top row being Positive and the bottom row Negative. When in use these charging terminals are connected in pairs so that all cells are in series.

☞ **Apply for copy, sent post free, Illustrated Booklet—**
"Photography tells the Story of the Tungstone Accumulator."

Please address all communications to the Distributors' Offices and Showrooms:
TUNGSTONE ACCUMULATOR CO., LTD.,
3, ST. BRIDE'S HOUSE, SALISBURY SQ., FLEET ST., LONDON, E.C.4
Telegrams: "Typify, Fleet, London." Telephone: Central 8157 (4 lines).

SOLD BY ALL DEALERS. T.24

Series of Patent Designs and Trade Mark Issued or Applied for in the Chief Countries of the World.

FREDERICK SMITH & CO.,

Incorporated in

The London Electric Wire Co. & Smiths, Ltd.,

ANACONDA WORKS, SALFORD, MANCHESTER.

HARD DRAWN H.C. COPPER LINE WIRE.

Special Tinned H.C. Copper Wire.

COPPER TAPES AND BINDERS FOR LINE WIRE.

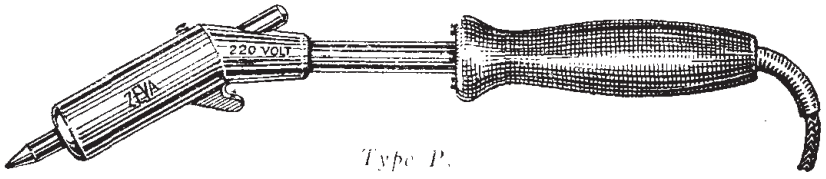
COPPER TROLLEY WIRE

SPECIAL NON-FOULING SECTIONS.

SILICIUM BRONZE WIRE

"C" Quality for Telephone Lines, &c.

Special Electric "Zeva,"
SOLDERING IRON
for Telegraph and Telephone purposes.



Type P.

Electric "Zeva" Soldering Irons have no need of spare-elements. As a consequence the costs of maintenance are nil.

N.V. ELECTRICITEITS MAATSCHAPPY "ZEVA,"
AMSTERDAM (HOLLAND).

Telegraphic Address: "ZEVA."

PEEL-CONNER
"LONG-LIFE" CORDS

The economics of the telephone cord, whether for the subscriber's set or the switchboard, provide a useful field for study by the telephone maintenance engineer.

There is much more in the subject than at first sight appears. When tendered prices are under consideration prior to an order being placed a leaning towards the lowest price must very generally be felt. There comes into play, however, the maintenance cost, often considerable, of sending a mechanic to replace or repair a worn-out cord, and also the great damage to the reputation of the service resulting from the trials of the subscriber in the period during which the cord by "scraping" and "cut offs" is fitfully announcing its approaching end.

The greater the useful life of the cord the less frequent these two burdens become, and the resulting reduction in the annual maintenance costs and the improved relations with the telephone using public will many times outweigh the slightly greater first cost of the "Long-Life" cord.

For over four years the Peel-Conner "Long-Life" cords have been used by many telephone administrations all over the world. Even in tropical countries there are administrations that, having tested and proved the merits of our "Long-Life" cords, have settled on their use as the standard for the future.

Quotations and full details of Peel-Conner "Long-Life" Cords and Cordage will gladly be furnished upon application being made to either of the addresses below.

PEEL-CONNER TELEPHONE WORKS

(Proprietors—The General Electric Co., Ltd.)

COVENTRY, ENGLAND.

HEAD OFFICE AND WORKS:

STOKE, COVENTRY.

Telephone: COVENTRY 1310.

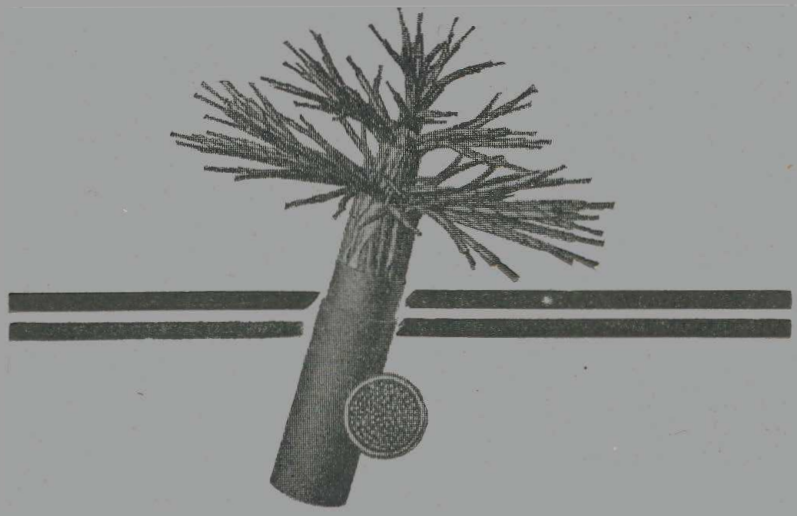
Telegrams:
"SPRINGJACK," COVENTRY.

LONDON OFFICE:

MAGNET HOUSE,
KINGSWAY, W.C.2.

Telephone: REGENT 7050.

Telegrams:
"Peelcontel, Westcent, London."



Where the Cables come from.

J. & P. Cables are extensively used in the National Telephone Service—and in constantly and consistantly increasing quantities.

And is it so surprising that our business in this direction, both at home and abroad, should have developed so rapidly, when one considers that into every foot of Trunk Telephone Cable that we manufacture, is built the concentrated experience of half a century?

This accounts for that "little more" in quality which means so much in service, and inspires, too, that "little more" in service which adds so much to quality.

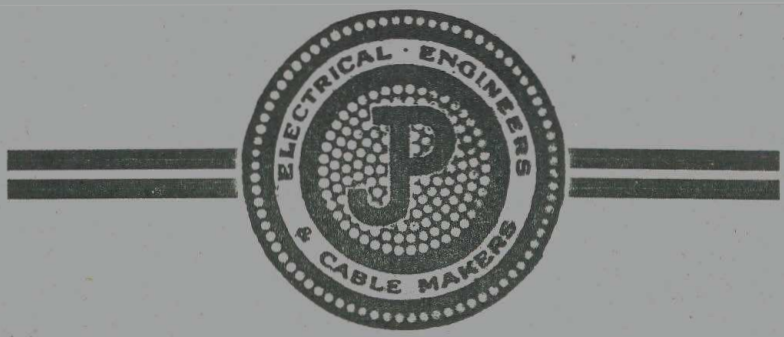
Literature on the above subject gladly on request.

JOHNSON & PHILLIPS, Ltd.

Specialists in the Transmission, Transformation and Control of Electricity.

Charlton, London, S.E. 7.

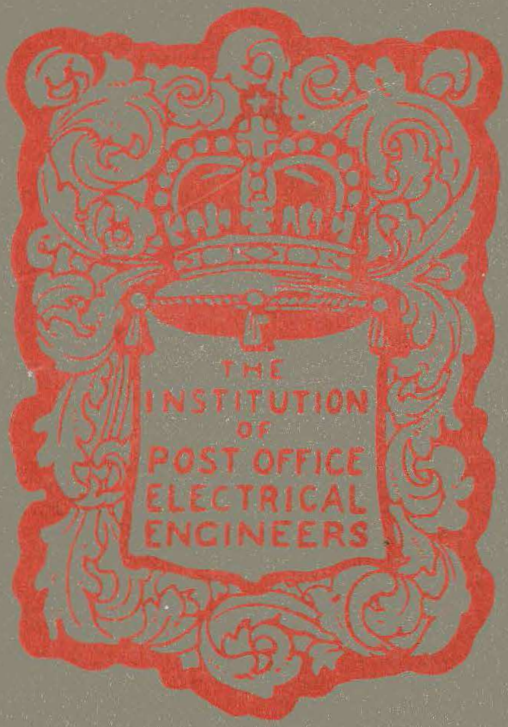
Branches in London (City), Birmingham, Bristol, Cardiff, Glasgow, Liverpool, Manchester, Newcastle-on-Tyne, Portsmouth, Southampton, and Belfast.



Printed by Birch & Whittington, Epsom, and
Published by The Electrical Review, Limited, at 4 Ludgate Hill, London, E.C.

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

POST OFFICE ELECTRICAL ENGINEERS LIBRARY



VOL. 19 PART 4

JAN: 1927

Price 1/6 net.

ADVERTISEMENT INDEX
see page xii.

The

LONDON ELECTRIC WIRE COMPANY & SMITHS, Ltd.

Manufacturers of

Every Description of Cables and Wires for Electrical Purposes

Cotton-Covered and Braided Wires. Cotton-Covered Strips and Cables. Silk-Covered and Enamel Insulated Wires. Multiple Cables. Flexible Cords. Cables and Flexibles for Wireless Work.

"Eureka," Nickelchrome and other High Resistance Wires.

Playhouse Yard, Golden Lane, London, E.C.1.

Telegrams: "*Electric, London.*"
Telephone: *Clerkenwell* 1388, 1389, 1390, 1391.

Pitman's Books for Engineers and Students.

New and Enlarged Edition

POOLE'S TELEPHONE HANDBOOK

and Guide to the Telephone Exchange.

By JOSEPH POOLE, A.M.I.E.E., Wh.Sc.

Seventh Edition, thoroughly revised and enlarged by 140 extra pages and 100 new illustrations.

This classic work, which is specially recommended by the Examiners of the City and Guilds Institute for candidates preparing for the examination in Telephony, has been thoroughly revised by the author in collaboration with experts on the G.P.O. Engineering Staff and other specialists in telephone engineering. The latest developments in every branch of the subject are now included.

728 pp., with 685 illustrations. **18/-** net.

In the Press.

The Director System of Automatic Telephony.

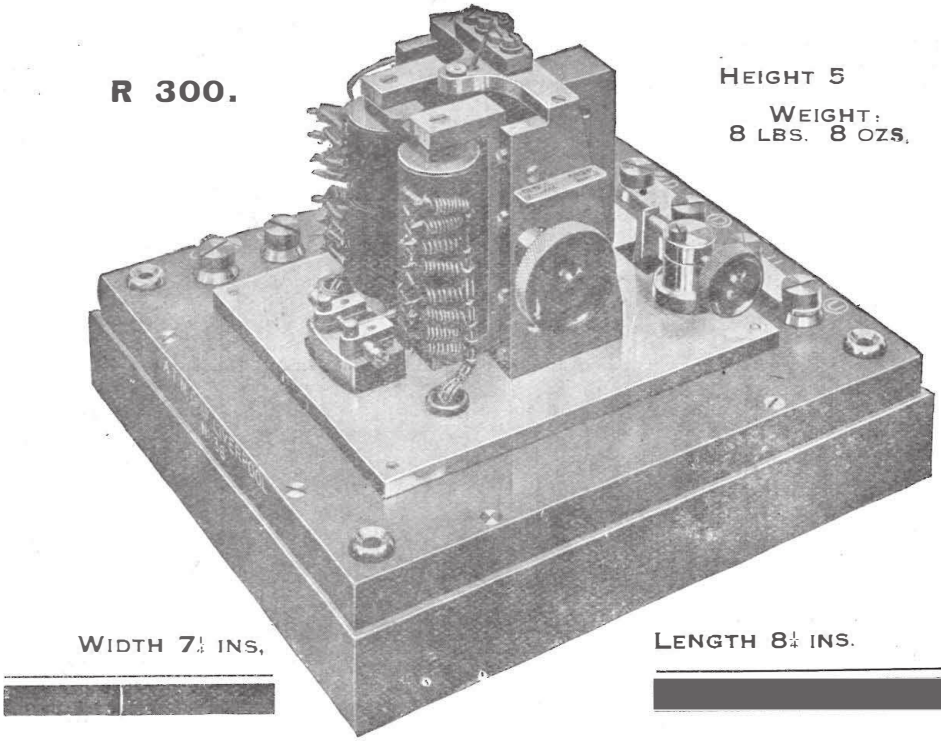
By W. E. HUDSON, B.Sc. (Hons.), Wh.Sc., A.C.G.I., Chief Assistant in the Engineer-in-Chief's School of Automatic Telephony, G.P.O.

This new work is intended for students of telephony, linesmen, traffic officers and telephone engineers who wish to make themselves familiar with the Theory of the Director System.

160 pp., with 155 illustrations. **5/-** net.

Full particulars post free.

Sir ISAAC PITMAN & SONS, Ltd., Parker Street, Kingsway, LONDON.



R 300.

HEIGHT 5

WEIGHT:
8 LBS. 8 OZS.

WIDTH 7¼ INS.

LENGTH 8¼ INS.

A.T.M.

GULSTAD RELAY

CABLE PATTERN

THIS pattern relay has been developed for specially difficult lines and submarine cables.

The adjustment of the contact carriage and the relation of the electromagnet cores to the armature system is of wide range and can be made in minute steps.

The frame in which the coils slide is very rigid and the relay is not susceptible to extraneous vibrations.

SEND TO-DAY
FOR
CATALOGUE
No. 39.

AUTOMATIC TELEPHONE
MANUFACTURING CO., LTD.

Head Office and Works:

MILTON ROAD,
EDGE LANE,
LIVERPOOL.

London Office:

NORFOLK HOUSE,
NORFOLK STREET,
STRAND, W.C 2

The Post Office Electrical Engineers' Journal.

A QUARTERLY JOURNAL.

CONTENTS FOR JANUARY, 1927.

COPYRIGHT.—The entire contents of this Journal are covered by general copyright, and special permission is necessary for reprinting long extracts, but Editors are welcome to use not more than one third of any article, provided credit is given at the beginning or end thus: "From the 'Post Office Electrical Engineers' Journal.'"

	PAGE
AN OSCILLATOR GIVING A SINUSOIDAL AND CONSTANT OUTPUT OVER THE COMPLETE AUDIO FREQUENCY RANGE—B. S. COHEN, M.I.E.E.	309
HOUSING THE BELL SYSTEM	325
EDINBURGH'S AUTOMATIC TELEPHONE EXCHANGES—H. W. DIPPLE, A.M.I.E.E.	335
OPERATING TIME LAG OF RELAYS	343
STRENGTH OF FLOORS IN TELEPHONE EXCHANGES—H. HILL, B.Sc., M.I.E.E.	347
A TELEPHONE REPEATER WITH REMOTE CONTROL—A. C. TIMMIS, B.Sc., A.M.I.E.E., and H. G. DAVIS, A.C.G.I., B.Sc., D.I.C.	351
THE ANGLO-BELGIAN (1926) CONTINUOUSLY-LOADED TELEPHONE CABLE—W. T. PALMER, Wh.Ex., B.Sc. (Hons.)	355
CORROSION OF LEAD-COVERED CABLES BY ELECTROLYTIC AND CHEMICAL ACTION	370
TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM	372
THE RUGBY RADIO STATION—E. H. SHAUGHNESSY, O.B.E., M.I.E.E.	373
THE FELLING OF THREE RADIO MASTS AT DEVIZES	382
NOTES AND COMMENTS	388
HEADQUARTERS NOTES	394
LONDON DISTRICT NOTES	404
THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS	406
LOCAL CENTRE NOTES	406
BOOK REVIEWS	424
STAFF CHANGES	425
COMMUNICATIONS	427
BOOTH-BAUDOT AWARD	428
CENTRAL LIBRARY	428

All communications with regard to advertisements to be addressed to:

The Advertisement Manager,
Post Office Electrical Engineers' Journal,
4, Ludgate Hill, London, E.C.4.

PUBLISHERS:

THE ELECTRICAL REVIEW, LTD., 4, LUDGATE HILL, E.C.

Price 1/6 net, post free, 1/9.

Annual Subscription, postage inclusive, 7/-, payable in advance.

— and then he got a trouble-free 'phone system!

THE exasperating breakdowns, delays and muffled speech encountered on ordinary phone systems fade away when an Ericsson System is installed.

Trouble-free, clear-speaking and carrying a tiny maintenance bill, it proves a wonderful business aid and soon repays its moderate initial cost. Stands up wonderfully well to hard wear.

Write to-day for free fully illustrated and informative pamphlet

ERICSSON TELEPHONES LIMITED

International Buildings, 67-73, Kingsway, London, Eng., W.C.2.

WORKS: BEESTON, NOTTS

Telephone: Gerrard 3003, 3004

Telegrams: Ericsson, Westcent London.

Ericsson

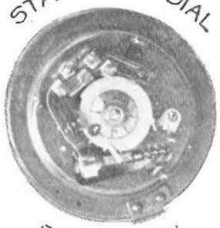
TELEPHONE EXCHANGE EQUIPMENT

SIEMENS

STANDARD DIAL FRONT VIEW

ADOPTED BY BRITISH POST OFFICE AND OTHER ADMINISTRATIONS ALL OVER THE WORLD

STANDARD DIAL



REAR VIEW

AUTOMATIC TELEPHONES

EDINBURGH

FAMOUS IN HISTORY ~ LEADS THE WAY TODAY

EDINBURGH AUTOMATIC TELEPHONE AREA

COMPRISING

CENTRAL | NEWINGTON | MORNINGSIDE | MURRAYFIELD

a total of

14,000 LINES

the

LARGEST NUMBER

ever

CUT OVER

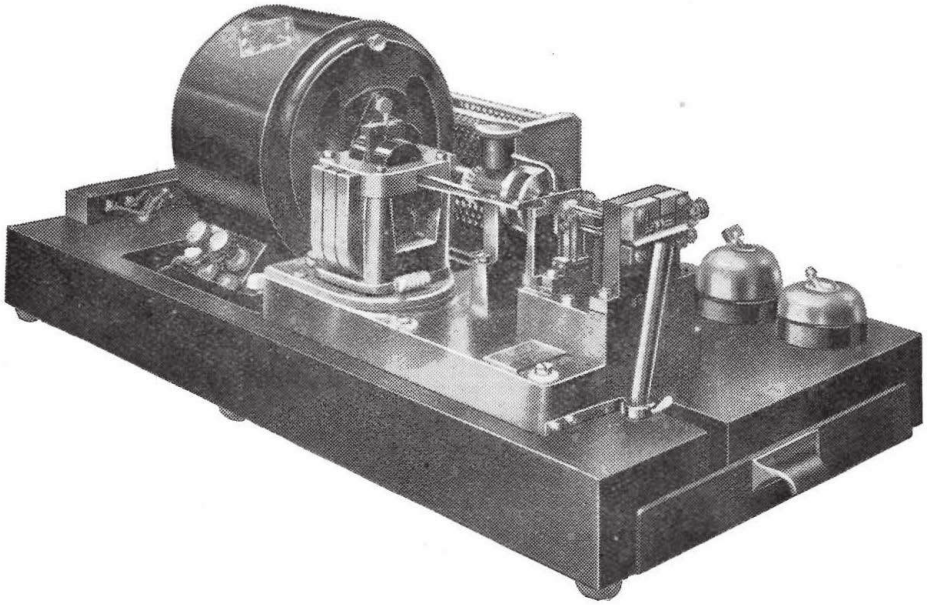
at one time in the

UNITED KINGDOM.

The complete equipment was designed, manufactured and installed by—

SIEMENS BROTHERS & CO., LTD., WOOLWICH, LONDON, S.E. 18.

CREED INSTRUMENTS



THE CREED RECEIVER

The Creed 1924 design Receiving Perforator is the acme of simplicity. With the instrument, motor, sliding resistance and switches mounted on a strong and light aluminium base, it forms a compact and serviceable unit. Speed ranges from 30-60 to 75-150 words per minute (with high speed motors, up to 200 w.p.m.), or a 3-speed change gear attachment can be fitted with a normal range from 20 to 180 w.p.m.

We are now manufacturing

START—STOP APPARATUS

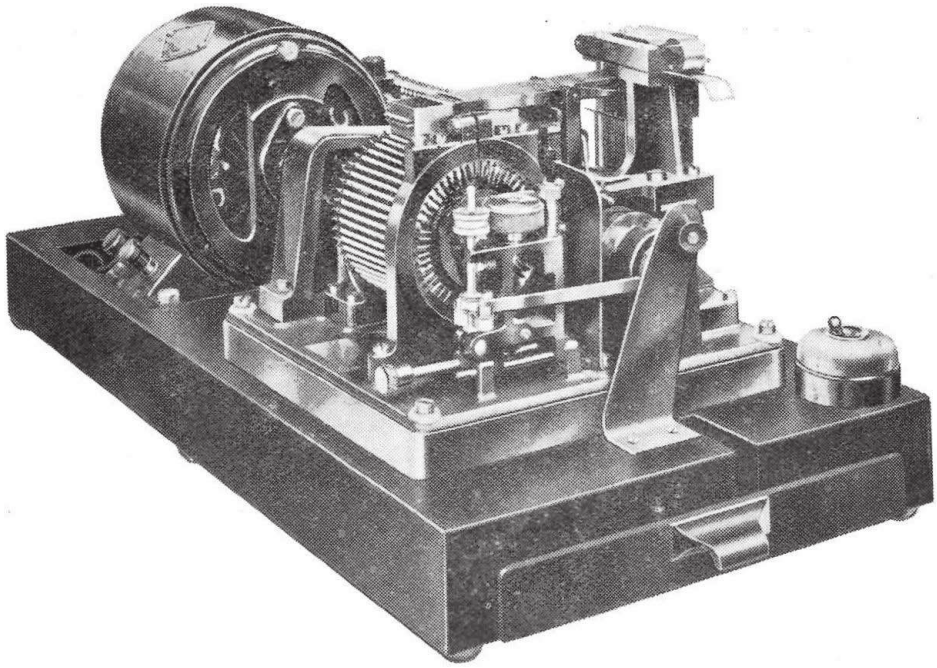
Write to us for particulars

CREED & CO., LTD.,

Telegraph Engineers,

Telephone : Croydon 2121.

CREED INSTRUMENTS



THE CREED PRINTER

The Creed 1924 design Printer, like the Receiver, is now mounted on a light aluminium base with the motor and sliding resistance forming a similar compact unit. Speed 150 words per minute. Tape wheel drawers are fitted in the base of both instruments.

MURRAY MULTIPLEX

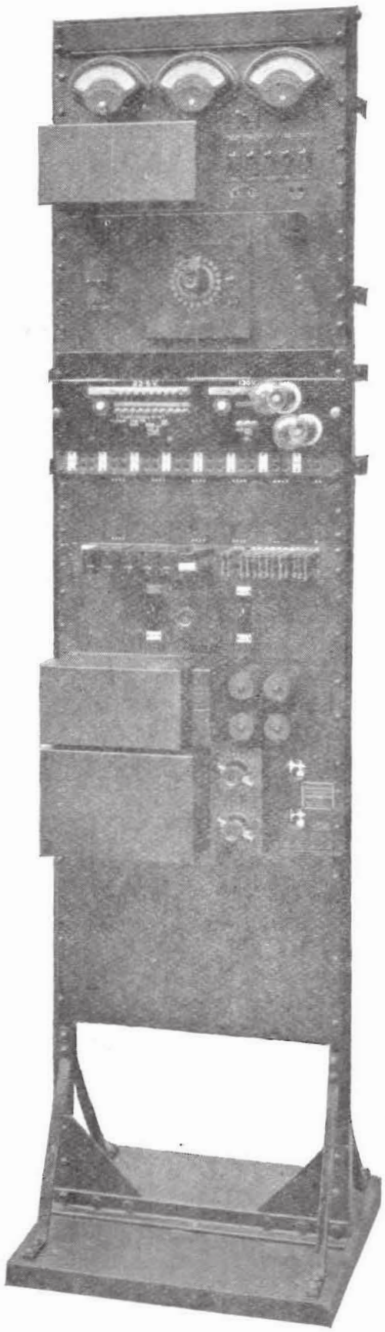
We also manufacture apparatus for this System.

Write to us for particulars.

TELEGRAPH WORKS
CROYDON, SURREY

Telegrams : "Credo, Croydon."

Standard
TELEPHONE REPEATERS



Salient Facts.

(1) The transmission efficiency of existing lines may be materially increased by the application of telephone repeaters; or substantial saving in first cost and operating charges may be effected in new installations.

(2) Telephone repeaters may be applied to improve the transmission of practically all circuits over which transmission is not normally satisfactory. Under the best conditions this improvement may amount to as much as nine-tenths of the normal equivalent length of the circuit.

(3) The reproducing quality of Standard telephone repeaters is so nearly perfect that any number of them may be successively inserted in a toll circuit without any distortion and loss of intelligibility by the action of repeaters themselves.

(4) Standard repeater equipment permits the use of conductors much smaller than are usually considered necessary for long distance transmission.

(5) Routine maintenance of Standard repeater equipment calls for few adjustments and little special attention. In general where there are few repeater sets at one point the equipment can be cared for by the normal maintenance force.

(6) Marked improvement in the continuity and reliability of telephone service may be obtained by the use of repeater sets, since small gauge loaded cable circuits may be utilised instead of open-wire lines.

(7) Greater satisfaction on the part of the subscribers and resulting increased revenues from toll service may be expected to follow the introduction of telephone repeaters into toll circuits over which the transmission would otherwise be of doubtful commercial grade.

Standard Telephones and Cables Limited

(Formerly Western Electric)

Connaught House, Aldwych, London, W.C.2.

'Phones: CENTRAL 7345 (10 lines).

Works:
HENDON.
NORTH WOOLWICH. NEW SOUTHGATE.

Branches: Glasgow, Leeds, Birmingham, Manchester, Liverpool, and Dublin.

THE
Post Office Electrical Engineers' Journal

AN OSCILLATOR GIVING A SINUSOIDAL AND CONSTANT OUTPUT OVER THE COMPLETE AUDIO FREQUENCY RANGE.

By B. S. Cohen, M.I.E.E.

Introductory.—The variation of sensitivity with frequency over the Audio Range for telephonic apparatus such as transmitters, receivers, and repeating coils, etc., may be referred to as the Frequency Characteristic of the apparatus in question. In a frequency characteristic is included nearly all the necessary information regarding the behaviour of the apparatus from a transmission standpoint, both as regards volume efficiency and articulation.

Apparatus has been designed in the Research Section to enable frequency characteristics to be quickly obtained. One of the main essentials is a source of alternating current readily variable over the important audio frequency range which is from 0 to at least 5,000 p.p.s. and capable of reaching to 10,000 p.p.s. if necessary, and which shall be practically pure in wave form (*i.e.*, harmonics present should be less than 5%) and should remain constant in voltage over the greater part of the range. Such a source of alternating current is essential not only for the plotting of frequency characteristics but it is also highly desirable in connection with a number of transmission measurements, such as transmission testing in repeater stations, transmission maintenance, etc., and also for general acoustic research.

If the frequency of the output is capable of being varied over the whole of its range by a single and simple operation such as the rotating of a variable condenser or inductance through a few

degrees, the use and value of the apparatus is much increased. With such apparatus it becomes possible to arrange for the complete frequency range, or any portion of it, to recur at a rapid rate, so that ordinary types of measuring instruments can be used to give an integrated reading for the rhythmically recurring frequency band. This opens up still another important field of use in connection with the rapid efficiency testing of telephone apparatus. (See "Telephonometry," B. S. Cohen, I.P.O.E.E. Paper No. 70; 1916).

The ordinary direct audio frequency valve oscillator is incapable of fulfilling these varied conditions, and even under the limited condition of ability to supply audio frequency current of comparatively pure wave form, although not constant volume, over the important audio range, the direct audio frequency oscillator becomes very costly and cumbersome.

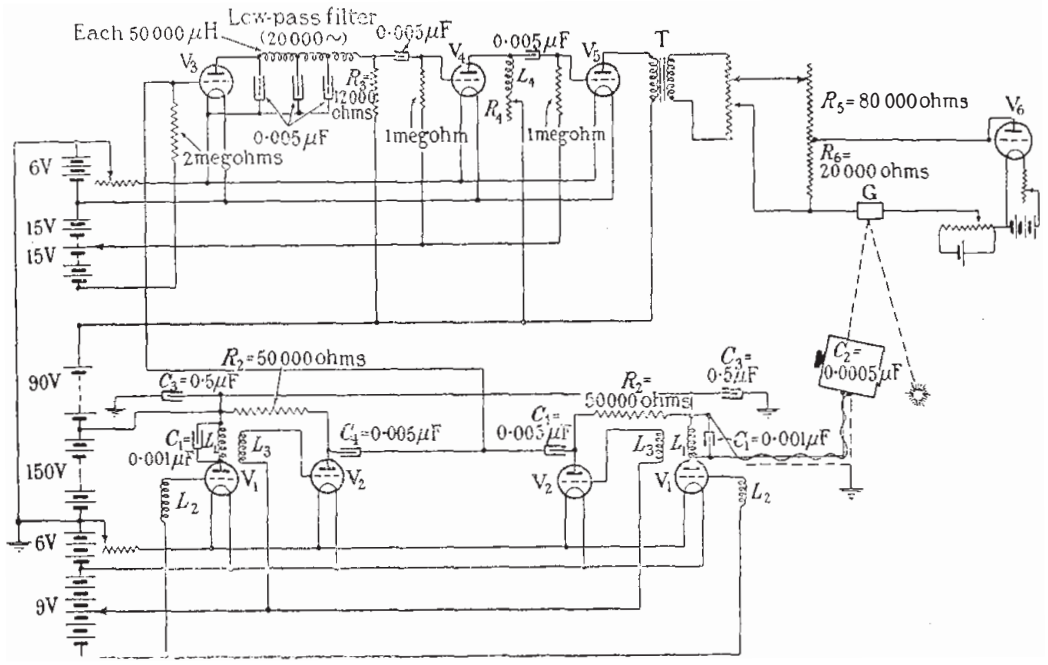


FIG. 1.—CIRCUIT OF COMPLETE TABLE PATTERN HETERODYNE OSCILLATOR.

The Heterodyne Oscillator.—In order to meet the full requirements, a heterodyne oscillator has been developed in the Research Section. The principle of operation is briefly as follows:—

Two valve oscillators, oscillating at ultra-audio frequencies are set up and the resulting oscillations are combined. One of these oscillators is maintained at a constant frequency and the other is capable of being varied from the same frequency by an amount which depends on the range of audio frequency required. If, for example, the fixed ultra-audio frequency is 30,000 p.p.s. and the second ultra-audio component can be varied from 30,000 to 25,000

p.p.s., a heterodyne or beat frequency, varying from 0-5000 p.p.s. will be obtained and similarly a variation of from 30,000 p.p.s. to 20,000 p.p.s. will give an audio range 0-10,000 p.p.s.

It should be noted that even in this extreme case, a variation of only $33\frac{1}{3}\%$ is required to obtain the 0-10,000 p.p.s. range and this percentage can be reduced still further by putting up the ultra-audio frequencies. It is this factor which renders it comparatively easy to obtain a constant output over the required range.

The heterodyne or beat audio frequencies can be separated from the ultra-audio component by small and simple filters and by rectification, and the separated wave can then be amplified to any

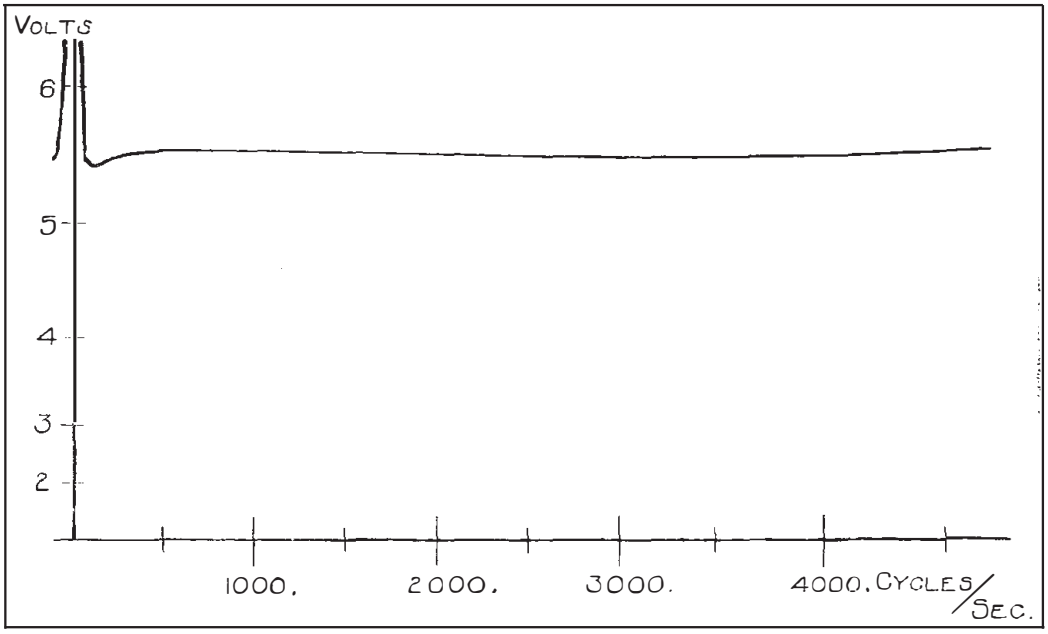


FIG. 2.—HETERODYNE OSCILLATOR. VOLTAGE-FREQUENCY CHARACTERISTIC.

extent desired. Apparatus of this type has been constructed in two forms, both of which are proving of great value.

Fig 1 is the circuit for a complete oscillator outfit.

V_1 V_1 are the two oscillator valves.

L_1 L_1 and L_2 L_2 are the plate and grid inductances and the former are tuned. In the case of the fixed ultra-audio frequency the tuning is only by a condenser C_1. In the case of the variable ultra-audio frequency the condenser C_1 is supplemented by a variable condenser C_2, which is combined with a camera in which characteristics can be photographically recorded. This will be described more fully later on.

The frequency of the fixed oscillator is set at about 30,000 p.p.s. and the other is so arranged that with the variable condenser at a few divisions above 0°, the same frequency is obtained, *i.e.*, zero

audio frequency and at 180° the frequency is 25,000 p.p.s., so that the audio frequency will be 5,000 p.p.s. The oscillations are picked up by coils L_3 L_3.

With each oscillator is associated a single stage amplifier V_2 V_2. This is mainly for the purpose of eliminating interaction between oscillators, but it has been found possible in the portable set described further on to dispense with these valves.

It should be noted here that the oscillator valves, coils and condensers are set up in two separated iron boxes which are earthed, and that the variable condenser is placed in an earthed screen and is connected up by a screened conductor.

The ultra-audio oscillators are operated on the resistance capacity principle (see R_2 R_2 and C_1 C_1) and the beat oscillations are connected to detector valve V3, which is operated by anode bend rectification. Finally, to eliminate all traces of ultra-audio

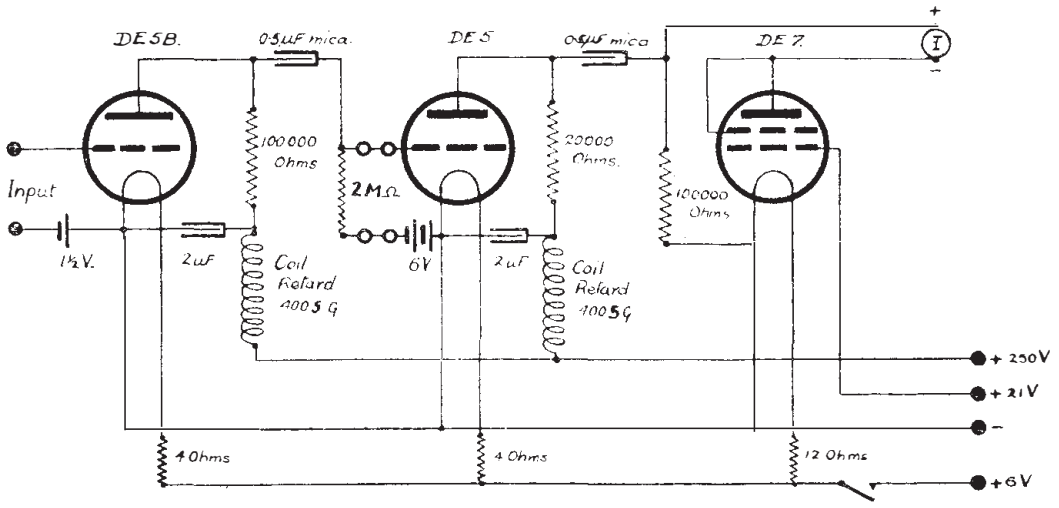


FIG. 3.—CIRCUIT OF STRAIGHT LINE DETECTOR AND AMPLIFIER.

frequency, a low pass filter is inserted in the plate circuit of the detector valve. This is a 3 section filter designed to block out all frequencies above 20,000 p.p.s.

The audio frequencies are then amplified by 2 stages of resistance-capacity coupled amplifiers and connected through a transformer T and potentiometer R_5 R_6 to an A.C. voltmeter of the Moullin type or to a special valve voltmeter as shown, consisting of a high period reflecting galvanometer connected through a diode rectifier. The galvanometer has a sensitivity of the order of 0.1 m.a. for full scale deflection on the condenser camera, and a natural period of the order of 1/25th of a second.

If this galvanometer be connected and arranged as shown in Fig. 1, it will record on condenser camera C_2 the frequency characteristic of the complete oscillator outfit itself. Such a

characteristic is shown in Fig. 2 and it will be observed that from a few cycles up to 4,500 p.p.s. the output remains constant at a voltage of 5.5 volts. This is due partly to the special output transformer T. with large cross-section core and interleaved slab coil primary and secondary windings.

With the secondary coupled to a non-reactive load, this transformer gives plenty of output at the lower frequencies; there is, however, a slight tendency of the output to fall off at the higher frequencies. In order to compensate for this, it will be observed that the plate of the first audio frequency amplifier is coupled to the grid of the second stage by an inductance L_1, which is about 0.2 henry, and a variable resistance R_4, which can be adjusted

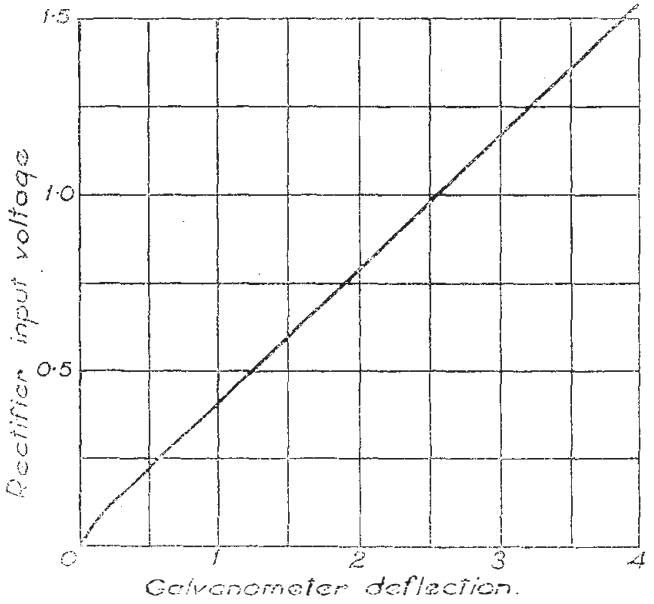


FIG. 4.—CHARACTERISTIC OF STRAIGHT LINE DETECTOR.

until the characteristic becomes flat. The high tension battery supplies are fed to the valves through chokes and condensers. These are omitted from the diagram Fig. 1.

The galvanometer rectifier just described does not give a straight line characteristic, but recently a modified galvanometer amplifier and rectifier has been designed and constructed which gives practically straight line rectification. Fig. 3 is the circuit and it will be observed that this consists of two stages resistance-capacity coupled amplifiers and a four-electrode valve D.E.7 with one grid and the plate in parallel and the second grid positively primed with 21 volts. Under these conditions the plate circuit becomes of very low impedance. This combination is a very satisfactory one and the characteristic, which is reproduced in Fig. 4, is practically a straight line.

Further details of the items comprising this testing set are given below :—

Valves V_1 V_1 V_3 V_4 and V_5 are all P.O. pattern V.T.24;

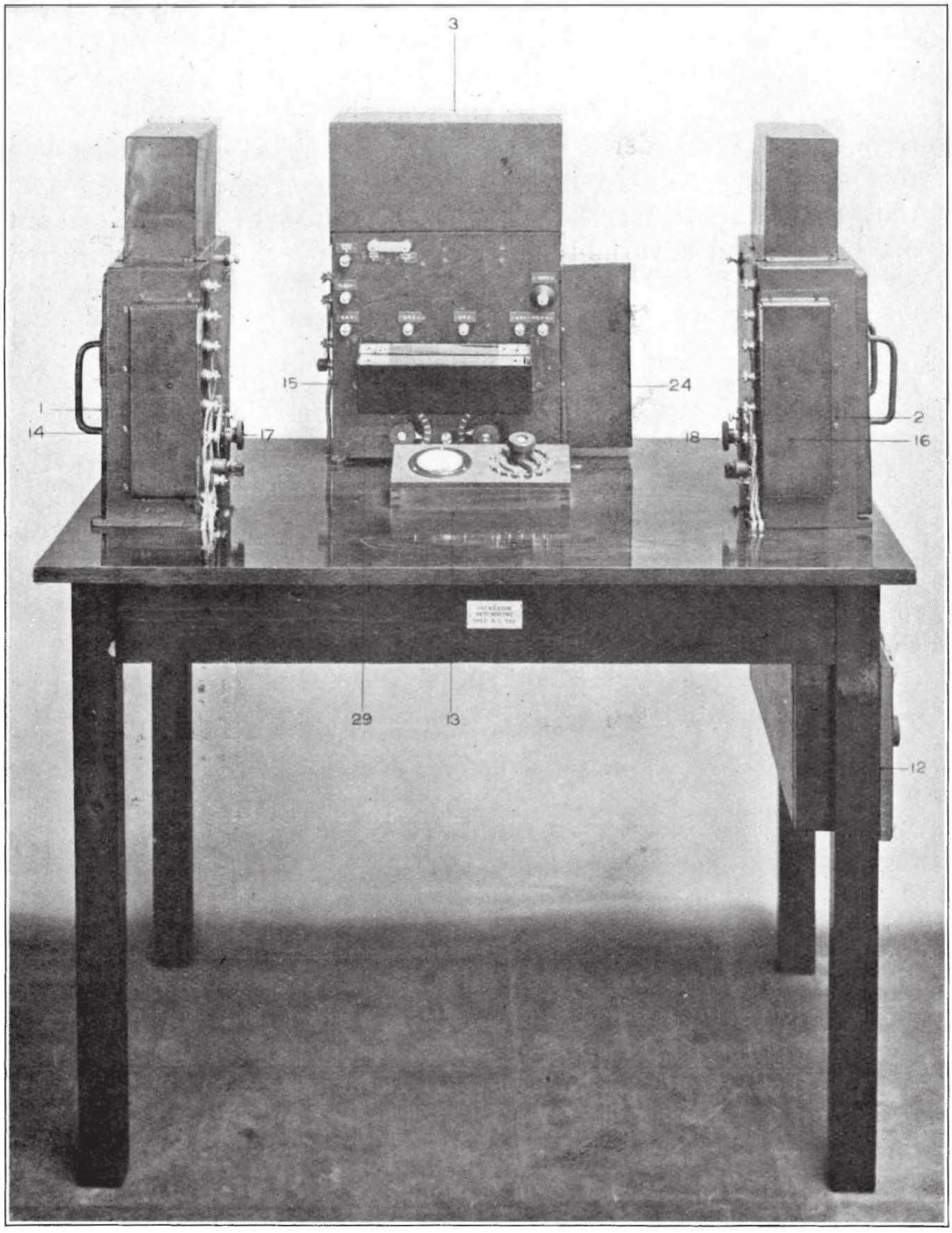


FIG. 5.—OSCILLATOR ASSEMBLY.

which corresponds to the Marconi-Osram L.S.5, and V_2 V_2 are V.T.4, corresponding to most R type valves.

Constancy of filament battery supply is an essential condition

for reliability of operation and a 100 amp. hour filament battery is employed.

L_1 L_1 are 20,000 μH coils; L_2 L_2 are 50,000 μH coils;

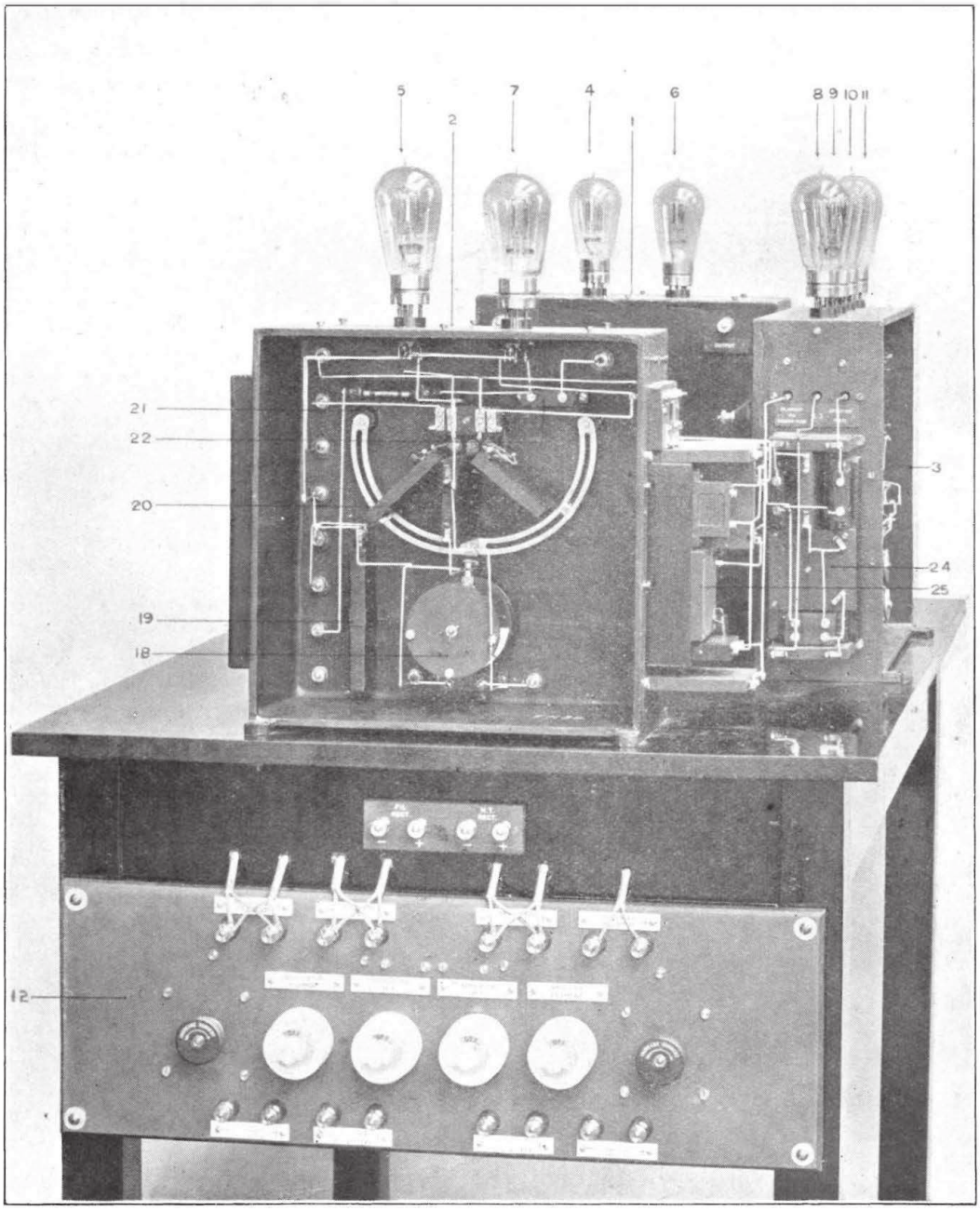


Fig 6.—Oscillator : End View.

L_3 L_3 are 10,000 μH coils; C_1 C_1 are .001 μF; C_2 is .0005 μF. Other electrical values will be found marked on Fig. 1.

Although not shown in the diagram, a variable condenser (max. 0.001 μF) is shunted across the input of detector valve V_3. As the value of this condenser is increased, the output falls off but

the wave form is improved. This condenser acts as a selective shunt with a tendency to reduce the amplitude of the harmonics more than that of the fundamental. Fig. 5 shows the complete oscillator asembly mounted on a table.

The two high frequency oscillators are on the left and right respectively, and the detector and audio frequency amplifier and filter are in the centre. On the right lower part of table is a battery panel.

Fig. 6 is an end view with the covers removed and shows the valve oscillator and coupler coils, which are mounted in rectangular ebonite slabs, the back of one of the oscillator condensers and also the battery panel with high and low tension connections are shown.

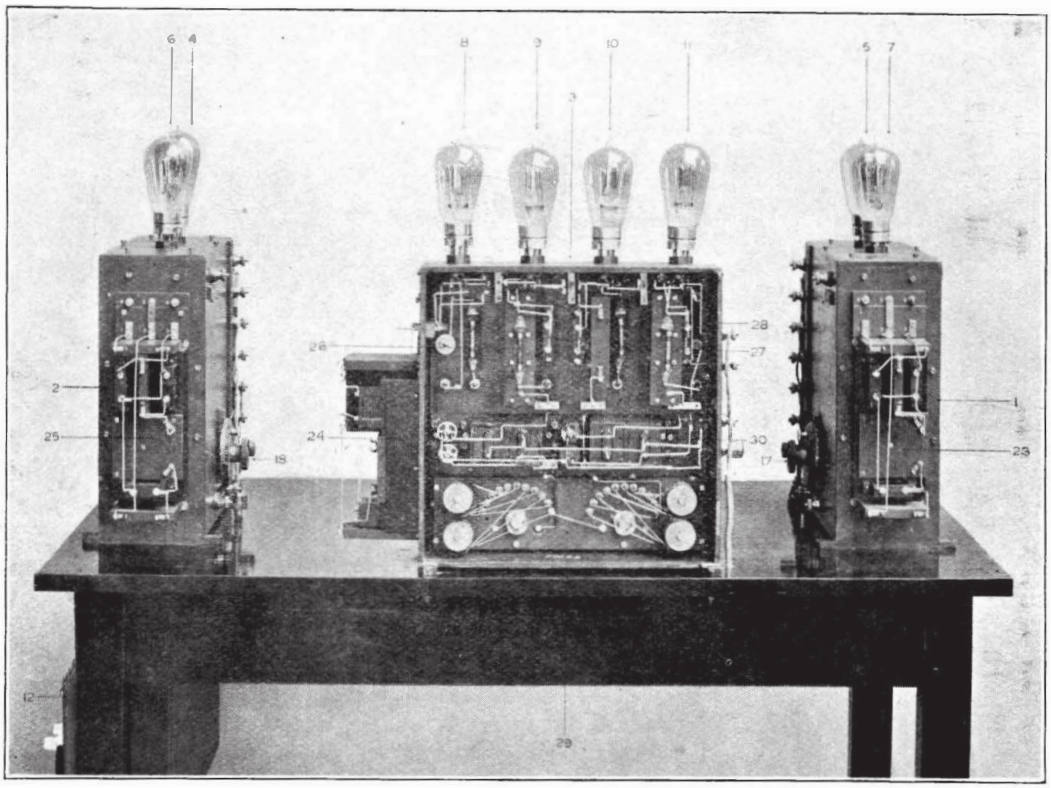


FIG. 7.—OSCILLATOR, DETECTOR AND AUDIO-FREQUENCY AMPLIFIER.

Fig. 7 shows the detector and audio frequency amplifier on the left. The low pass filter will be observed and similar filters will be noted on each of the high frequency oscillators. These have, however, not been found essential and are not used.

The H.T. feeding chokes and condensers are also to be seen in this illustration.

Fig. 8 shows the condenser camera with the cylindrical camera cover open, showing the drum surrounding the condenser to which the sensitized paper is attached and a developed characteristic is

shown *in situ*. The light of a Pointolite lantern reflected from the galvo mirror falls through the camera shutter when the latter is open and passes through a cylindrical lens, forming a spot of light on the paper. The large wheel to rotate the condenser is graduated in degrees and must be rotated very slowly. Two condensers, each of 0.0005 μF., are incorporated in the camera One of these has a straight line relationship between frequency and angle, whilst the other is a square law condenser. Either of them can be used individually. Fig. **9** is a general view of the recording apparatus comprising the lantern, galvanometer, and condenser camera. A separate wheel will also be noticed in the foreground.

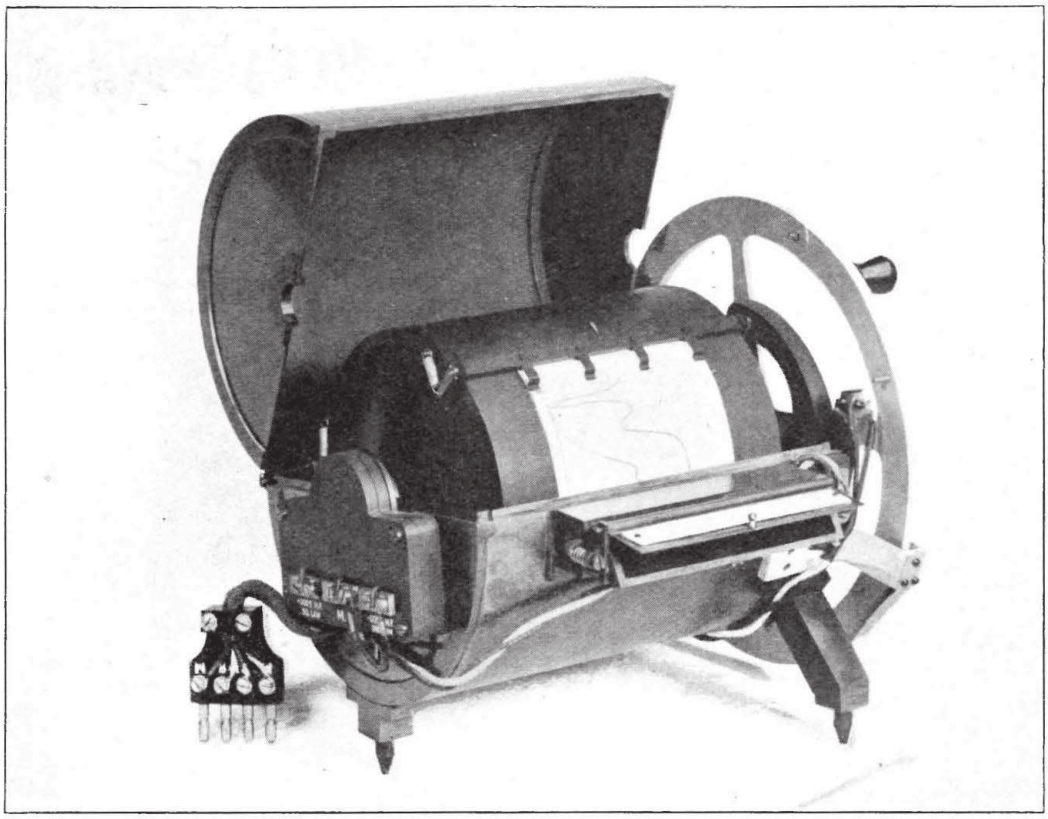


FIG. 8.—CONDENSER CAMERA.

This can be coupled to the camera wheel to give the latter an extremely slow motion when desired.

Some indication of the purity of the wave form is given by the oscillograms reproduced in Fig. **10** for audio frequencies ranging from 38 p.p.s. to 1000 p.p.s. Quantitative measurements of the actual impurity of the wave form have been made by measuring the capacity of a condenser and the method would have indicated the existence of any harmonic not less than 5% of the fundamental amplitude. As no trace of discrepancy was found it may be concluded that impurities are less than 5% of the fundamental.

Portable Pattern Heterodyne Oscillator.—The circuit arrangements adopted for the portable pattern oscillator are shown in Fig. **11**. It will be observed that the circuit has been simplified and by the omission of the high frequency amplifying valves only 5 valves are required, and these are all dull emitter valves, thus considerably reducing the total filament current required. In other respects this oscillator is generally similar to the instrument previously described. Output characteristics of this instrument are given in Fig. **12**, and as the load resistance is given the power outputs can be obtained. With a 1000 ohm load, the average voltage is of the order of 12.5 volts over the range, and with a 600

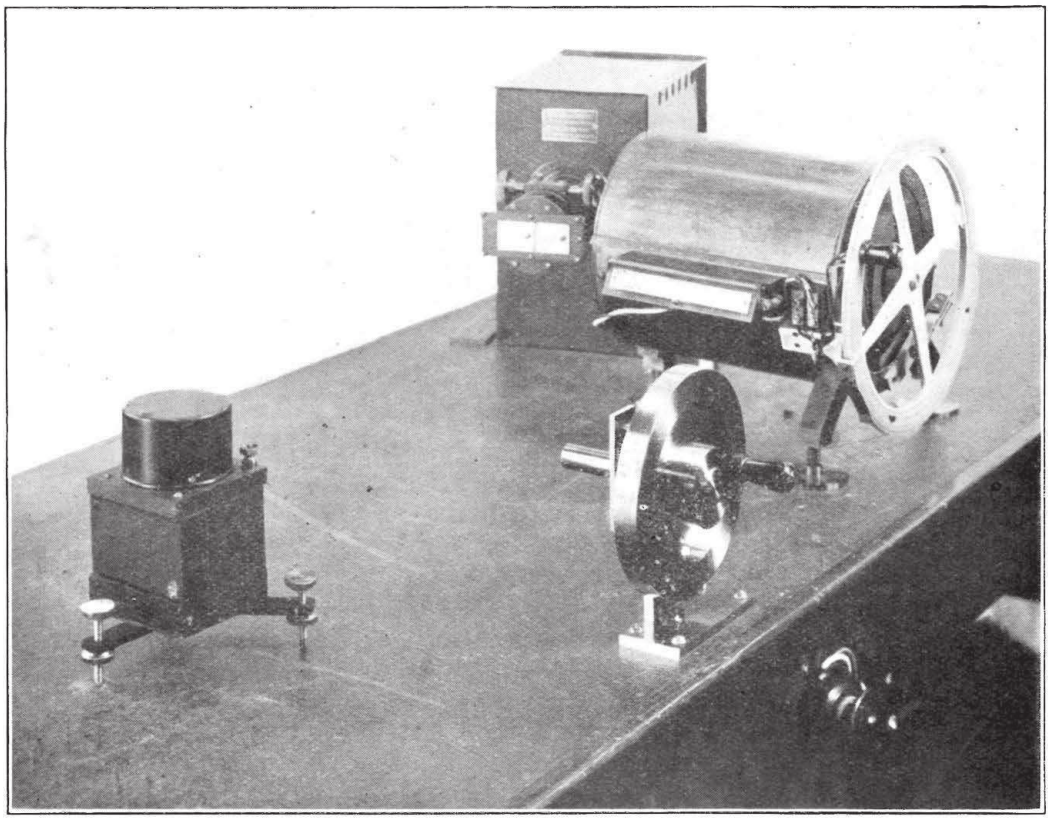


FIG. **9**.—RECORDING APPARATUS: GENERAL VIEW.

ohm load the average voltage is about 8.5 volts. The power available is of the order of 120—150 milliwatts, which is ample for most purposes. The general arrangement of this portable set is shown in Fig. **12***a*.

Notes on the uses of Heterodyne Oscillators.—The simplest use for the heterodyne oscillator is as a source of sinusoidal electric power of constant volume and of variable frequency over the audio range. For this purpose the frequency control can be a single air condenser with a straight line frequency characteristic and provided with a vernier to enable zero frequency to be obtained at any

convenient point of the condenser scale (say 10 degrees). A calibration of any other point on the condenser scale for frequency is then all that is required, and this can be effected by operating a telephone receiver from the oscillator and adjusting to the required frequency by means of a tuning fork or frequency bridge. The condenser can then, if desired, be provided with an adjustable scale calibrated direct in frequency. It is sometimes found convenient to use two condensers of different ranges in parallel, one of which is provided with a vernier for zero adjustments. For example, if

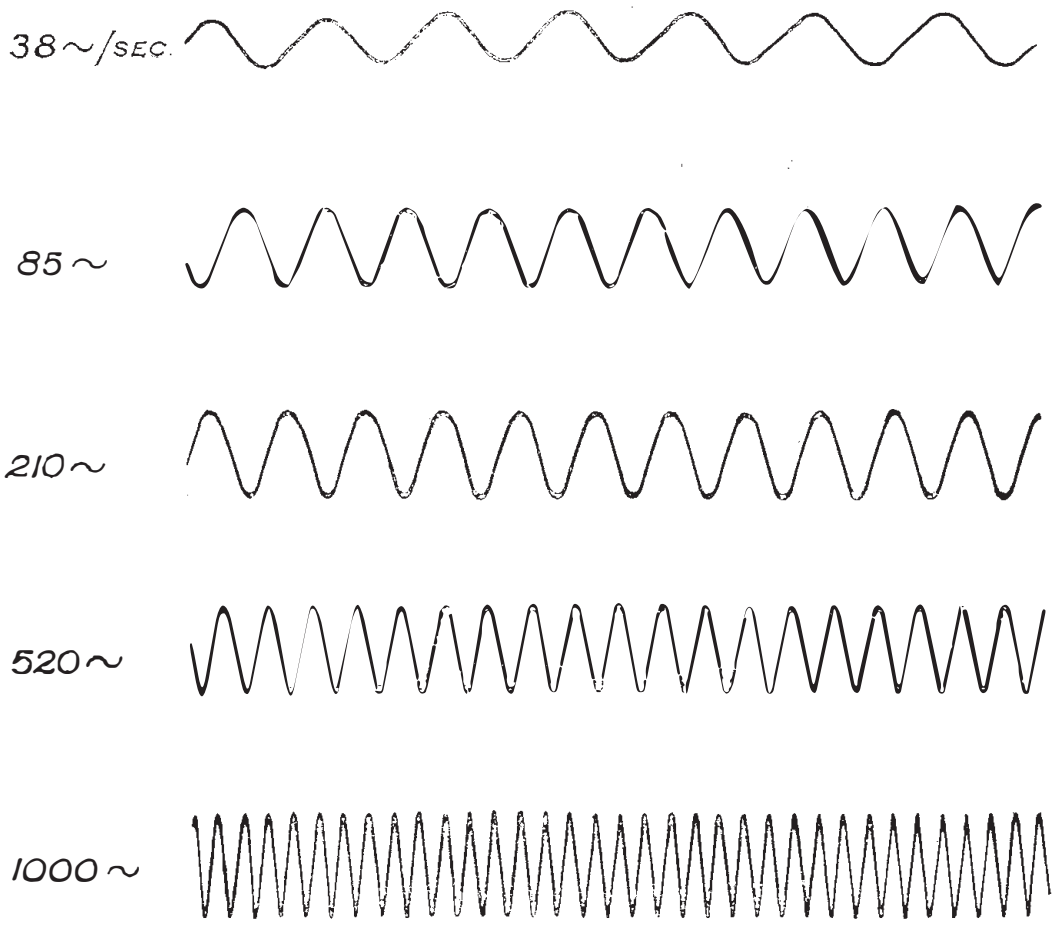


FIG. 10.—WAVE-FORM OSCILLOGRAM.

one condenser be 0.005 μF and the other 0.0025 μF, and the larger condenser give a frequency of 5000 p.p.s. at 180 degrees the smaller one will give a range up to 2,500 p.p.s., with a correspondingly more open scale.

The next use of the oscillator is to feed an electro acoustic transformer in order to obtain pure sounds over the audio range. Moving coil electro magnetic receivers can be used for this purpose, as also can specially damped Bell receivers, also condenser receivers. In an article in the last issue of this Journal on "A

High Quality Telephone Transmission System," will be found a description of a moving coil receiver which is suitable for this purpose. (See Figs. **7**, **8**A, B and C, and electro-acoustic characteristic Fig. **10**.) For determining transmitter characteristics the output of this receiver when actuated by the oscillator can be used to operate the transmitter and the output of the latter recorded either point by point or photographically on the condenser camera.

Correction can of course be made for the non-uniformity of the receiver characteristic by means of the calibrating curve just referred to (Fig. **10**, Page 248, *P.O.E.E.J.*).

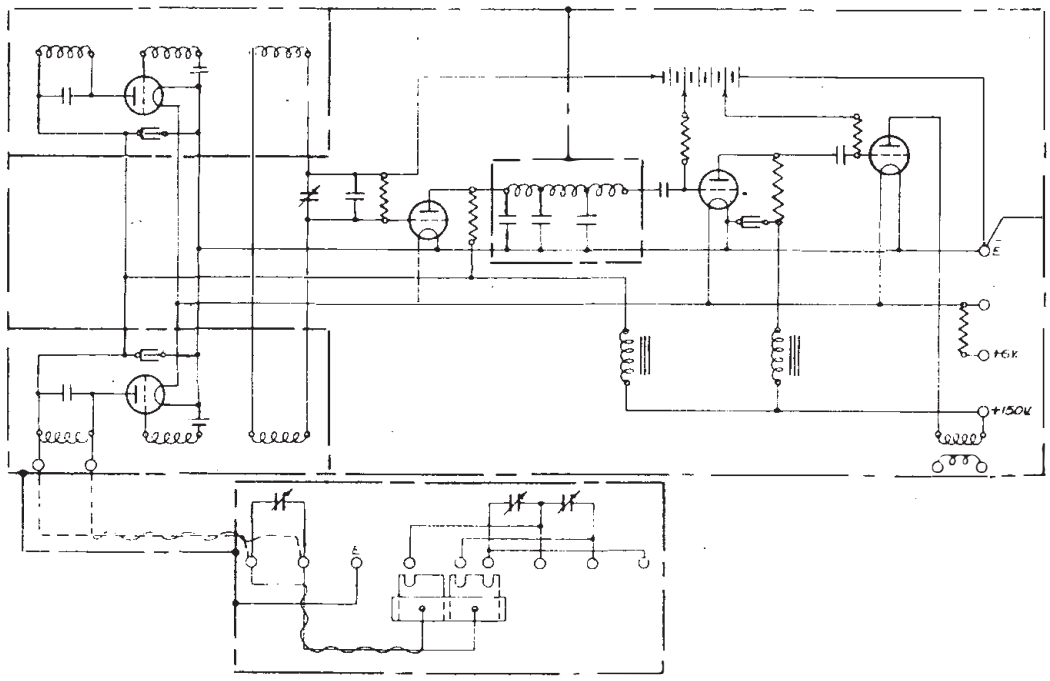


FIG. **11**.—CIRCUIT OF PORTABLE PATTERN OSCILLATOR.

When investigating the characteristics of telephone receivers and loud speakers, these instruments can be actuated by the oscillator and the acoustic output recorded on the condenser camera by means of a suitable " pick up " transmitter which may be condenser, thermophone or electro magnetic type, *e.g.*, the eddy current transmitter illustrated in the last issue of the Journal (Fig. **1**, Page 238, and calibration curve Fig. **6**, Page 244). Various precautions are necessary in taking such acousto-electric and electro-acoustic characteristics in order to get results which truly represent the behaviour of the instrument under investigation. For example, if a loud speaker be tested by means of an eddy current transmitter placed at a few feet from the loud speaker in an ordinary room, the characteristic obtained will include standing

waves produced by reflection from the walls of the room, and also from the front of the eddy current transmitter. These will of course vary with every change in the position of the instruments with regard to each other and to the room walls.

These standing waves are of importance to study, as they will always occur to a more or less considerable extent under the normal conditions of use of a loud speaker; it is necessary, however, to eliminate them when investigating the absolute or comparative efficiencies of the loud speaker, and to do this it is necessary to carry out tests under non-reflecting conditions, *i.e.*,

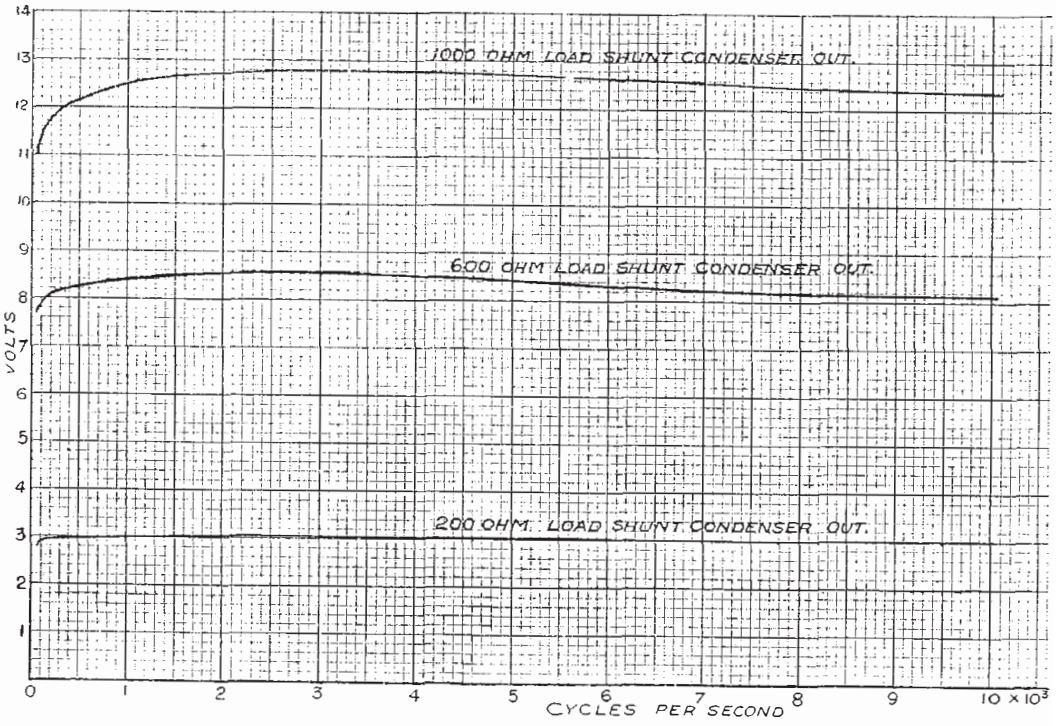

1000 OHM LOAD SHUNT CONDENSER OUT.
600 OHM LOAD SHUNT CONDENSER OUT.
200 OHM LOAD SHUNT CONDENSER OUT.
VOLTS
CYCLES PER SECOND
10 x 10³

FIG. 12.—OUTPUT CHARACTERISTIC OF PORTABLE OSCILLATOR.

in the open air and with the acoustic pick up at as great a distance as possible from the loud speaker and with its reflecting surfaces as far as possible covered with cotton waste or some other sound absorbing materials.

The alternative method is to carry out the measurements in a suitable chamber or room provided with sound absorbing draperies or materials. Elaborate experiments have been carried out at Dollis Hill in connection with the construction of a special room arranged for this purpose, but details will be outside the scope of this article.

Rhythmic Oscillations.—Reference has already been made at the beginning of this article to the use of a rhythmically recurring frequency band and an integrating measuring instrument for the

purpose of rapidly testing the transmission efficiency of telephonic apparatus, etc. For this purpose it is necessary to drive the frequency control condenser from some convenient source. Clock work and electric motors have both been used and by suitably arranging fixed capacity condensers any part or the whole of the audio frequency band can be utilised. Condenser circuit arrangements for obtaining these results will be found in Fig. **11**.

If the recurrence be of the order of five times per second, an ordinary commercial needle or reflecting pattern microammeter will give a steady deflection.

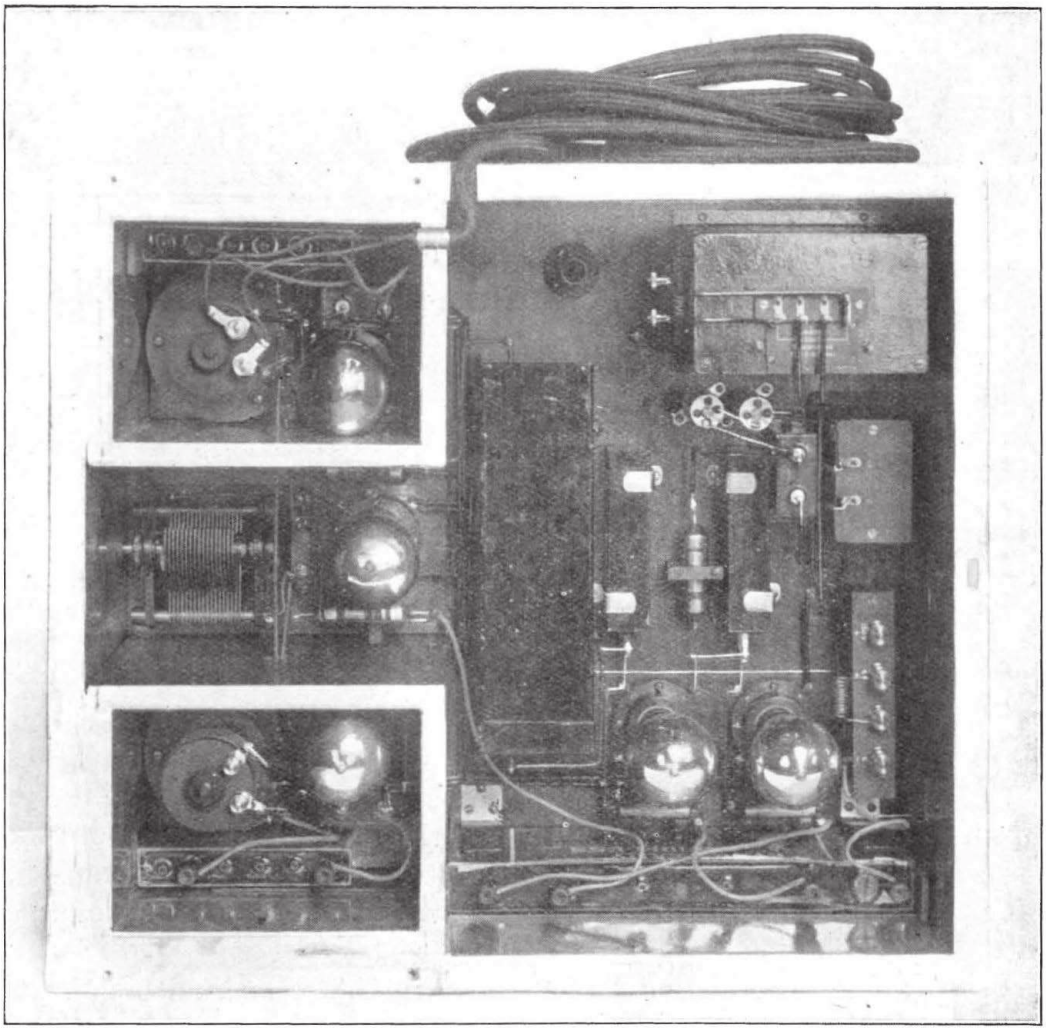


FIG. **12***a*.—PORTABLE OSCILLATOR.

The rhythmic oscilator outfit will, it is expected, be of great value in replacing the voice and ear for the rapid bulk testing of new deliveries of transmitters and receivers and also for the transmission maintenance of these instruments *in situ*, and apparatus for this purpose is now under trial with promising results. Similar

apparatus is also being tried out for line and circuit testing and for cross-talk measurements.

Some characteristics obtained with the Heterodyne Oscillator Outfit.—In conclusion a brief reference will be made to some of the typical results obtained. These, as well as some of the other illustrations included in this article, are reproduced by kind per-

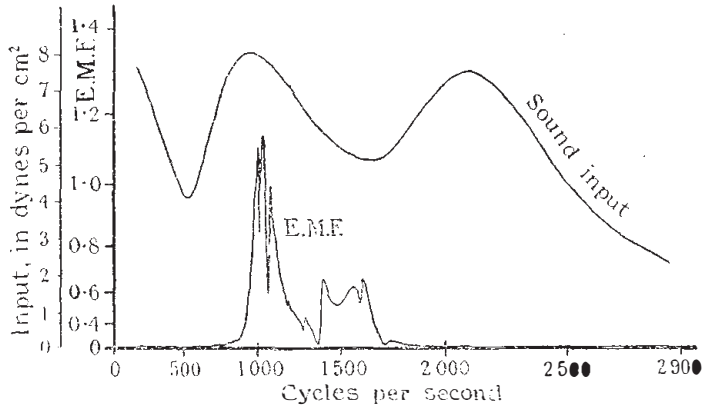


FIG. 13.—CHARACTERISTIC OF TRANSMITTER NO. 1 C.B.

mission of the Institution of Electrical Engineers from a paper entitled "The Frequency Characteristics of Telephone Systems and Audio Frequency Apparatus," B. S. Cohen, A. J. Aldridge and W. West. Vol. 64, part 358, October, 1926.

Fig. **13** shows the characteristic of a No. 1 C.B. transmitter. The sound input in dynes per square centimetre from a moving coil receiver is recorded, and also the corresponding voltage output of the transmitter when connected in a normal manner.

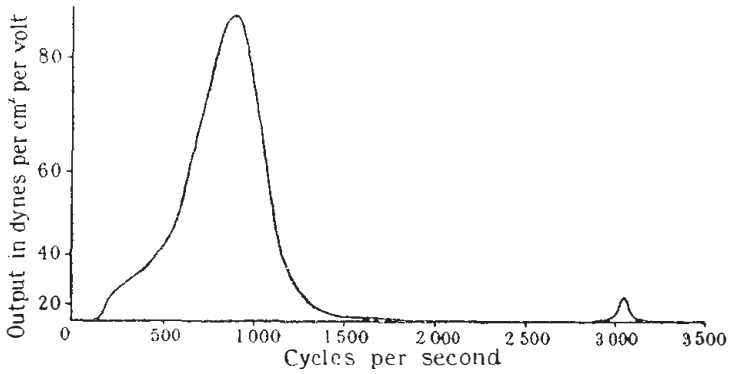


FIG. 14.—CHARACTERISTIC OF BELL RECEIVER HELD TO EAR.

It will be observed that there is comparatively little if any response until a frequency of the order of 700 p.p.s. is reached and that resonance occurs at about 1000 p.p.s. There is a flat resonance peak due to mouthpiece at 1500—1700 p.p.s. and practically no response beyond 1900 p.p.s.

Fig. **14** is the characteristic of a Bell receiver. The receiver was placed against an artificial ear, so that the output was damped in the same way as it would be in practical use. The receiver commences to respond at about 150 p.p.s. and output rises rapidly to a maximum at about 900 p.p.s. Between 1,500 and 2,900 p.p.s. there is very little response and there is a small resonance point just above 3,000 p.p.s. This is due to another mode of vibration of the receiver diaphragm. This charcteristic is very different from that of the receiver not held against the ear, but for further details reference must be made to the I.E.E. paper.

Fig. **15** is the overall acoustic-electric-acoustic characteristic of a trunk connection. The circuit is shown in the figure and consists of 32 standard miles of non-reactive artificial cable, equivalent to a perfect continuously-loaded telephone line without cut-off.

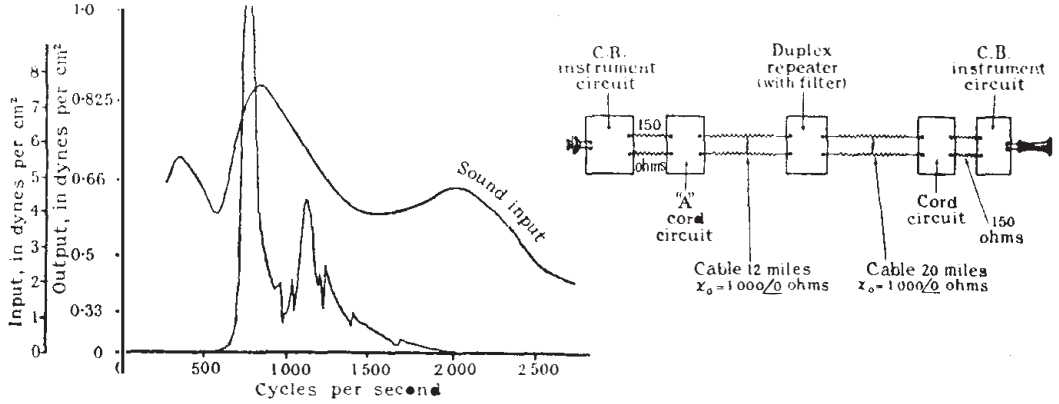


Fig. **15.**—Characteristic of Complete Circuit (Trunk).

A duplex repeater is inserted as shown and this has the usual filter cutting off about 2,200 p.p.s. Standard C.B. cord circuits are used and 150 ohms subscribers' loops. Also Standard C.B. instruments and a No. 1 C.B. transmitter and 60 ohm Bell receiver (not held to the ear). The overall characteristic, it will be observed, is mainly a combination of the transmitter and receiver characteristics and the effective audio frequency band is limited to about 600—2000 p.p.s.

Space will not permit the inclusion of further characteristics of other apparatus, lines and circuits, but it is thought that sufficient has been given to demonstrate the possibilities of the method, and it may fairly be said in conclusion that a new and powerful method of investigating the efficiency of telephonic systems and apparatus is now available which forms a ready means of enabling the effect of change in construction and design to be conveniently observed, measured and recorded.

HOUSING THE BELL SYSTEM.

[*We are indebted to the American Telegraph and Telephone Coy, for permission to reproduce this article from the July issue of the "Bell Telephone Quarterly" and also for the loan of the blocks.*—EDS., *P.O.E.E.J.*]

WE are celebrating this year the telephone's fiftieth birthday. As we look back over this relatively brief span of time we cannot but be impressed by the signs on every hand of the phenomenal growth and progress in the industry. The great advancements in the art of communication itself, through the comprehensive development and research activities carried on by the System, and the marked progress made in the construction and operating activities all form interesting stories in themselves. Similarly, there has been great progress in the other essential and related phases of the business, the scope of which at first is perhaps scarcely realized.

Among the more important of these related activities is that of housing all the component parts of this vast enterprise. There are close to 6,000 buildings in the System ranging in size from small and isolated repeater stations on the western prairies housing the appartus which makes communication possible from coast to coast, to huge combination office and equipment buildings in the midst of metropolitan traffic, through a list comprising garages, warehouses, factories, shops, office buildings and even hospitals. It doubtless will be of interest, therefore, to review the character and scope of the housing phase of the System's activities starting with the famous garret in Court Street, Boston.

In the earliest days of the telephone service, the housing problem was a simple one. A very small switchboard, simple in character and easily moved if necessary, was placed in some convenient location, usually in rented quarters, and from that switchboard wires were run one by one as needed either on poles or over housetops to the premises of those desiring service.

It will be seen, therefore, that in these early days, the housing activities were substantially no different in a particular city than those of the local merchant. Almost any space fairly centrally located with respect to the customers to be served was entirely suitable, particularly as no undue expense or inconvenience was involved in relocating the equipment and wires and personnel. It may be of interest to mention here that the first commercial telephone central office was established at New Haven in 1878, and occupied, as did a great many subsequent offices in different parts of the country, a few hundred feet of space in rented quarters.

In a relatively few years, however, as the telephone became more and more a part of the community life the picture changed. The rapid increase in the number of subscribers brought about the necessity for more elaborate and expensive switchboards, which in turn introduced more exacting requirements as to the location and character of the building space. This problem multiplied as the art developed, each subsequent advancement introducing new problems in the building phase of the work. In fact, only within the last few years, important changes in the art such as improved transmission developments and the dial telephone brought about fundamental problems not heretofore encountered.

How different, then, is the problem of to-day, particularly in the large cities. Each of the buildings must be placed in some definite location, and it is necessary to plan this well in advance and to direct the growth of the plant toward that location even though the building may not be erected for some years. Otherwise, very serious and costly rearrangements of plant would be necessary at the time the office is opened. Furthermore, each building must be planned to fit the particular circumstances surrounding the central office in question. Not only must very careful consideration be given to the erection of the immediate building, but the plans must provide for ready expansion to care for the telephone growth without excessive cost or reaction on the service. Moreover, suitable real estate at the theoretical wire center may be unobtainable in some cases, in which event studies must be made weighing the costs of various available sites near the wire center against the varying lengths of conduit and cable runs involved in each case.

The extent of our building activities is perhaps most strikingly illustrated by the structures shown in Fig. 1, which portrays an imaginary city composed of Bell Telephone buildings.

Of course, the bulk of our buildings are used for housing central office switchboards and associated personnel and the records indicate that the Schenley central office building at Pittsburgh erected in 1886 was one of the first, if not the very first, building planned and erected for this purpose.

With the Schenley building as a background let us survey the situation as of to-day. There are some 2,000 or so of these company-owned properties, representing a capital investment of close to $50,000,000 in land and something over $200,000,000 in buildings. Their aggregate area is well over 30,000,000 square feet, of which about 75% is in non-combustible buildings, and in addition to providing for central office switchboards, they provide working space for about 250,000 employees.

The scope of the construction activities involved in the erection of these numerous buildings is apparent. However, perhaps a

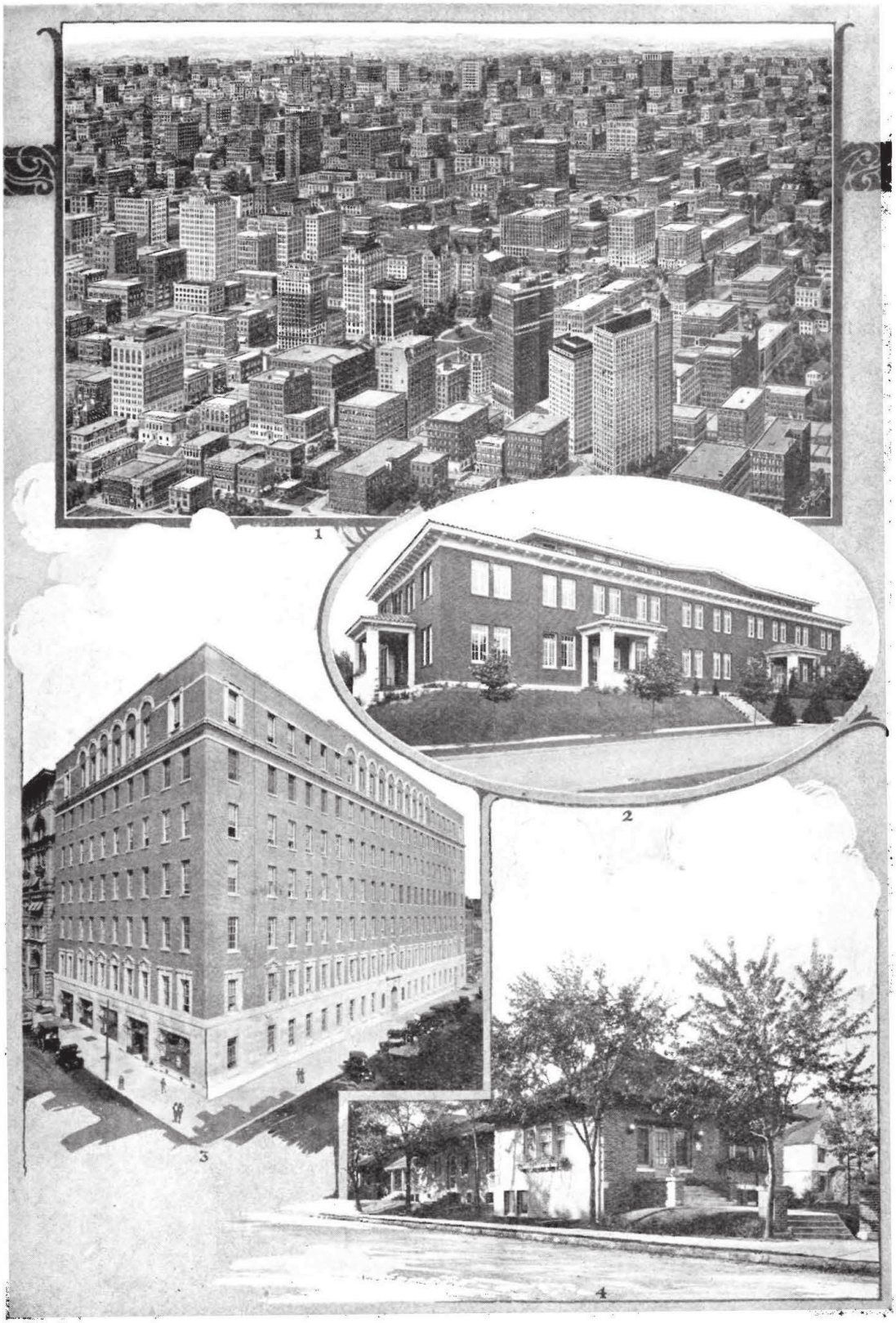


FIG. 1.—A TELEPHONE CITY—ONE-FIFTH OF THE BUILDINGS OWNED BY THE BELL SYSTEM.
FIG. 2.—A MULTI-UNIT OFFICE IN A RESIDENTIAL DISTRICT.
FIG. 3.—A MULTI-UNIT OFFICE IN A METROPOLITAN BUSINESS DISTRICT.
FIG. 4.—A SMALL SUBURBAN OFFICE.

few facts as to the magnitude of the housekeeping involved in their upkeep will be of particular interest.

The Bell System keeps house just as truly as a housewife does, but on a gigantic scale. It requires the entire working time of over 6,000 people to insure that all company-owned buildings are adequately heated, lighted, cleaned and serviced. It requires the services of close to 2,500 people to cook for and wait upon Bell System employees who secure lunch or other meals in telephone buildings—in fact, this is another closely related activity which would make an interesting story in itself. Hundreds of electricians, machinists, carpenters, painters, and other mechanics are regularly employed for the making of minor alterations, repairs and replacements.

Aside from those engaged in the architectural and construction phases of the work, there are several hundred telephone engineers in the System whose principal activities are concerned with the problems involved in planning central office buildings. A new building of this character involves consideration of the relative advantages of the different pieces of property available. It includes the preparation and careful examination of preliminary plans covering the more promising building and equipment arrangements which might be employed for the property finally acquired.

The facility with which these layouts could be expanded from time to time as required to care for growth, the advantages from an operating and maintenance point of view, and the relative costs are carefully weighed. The most desirable scheme is then fully developed. This requires careful study in collaboration with the architect and the other departments of the company of a great variety of interesting problems ranging from each detail involved in the arrangement of the central office equipment to the broader considerations affecting the occupancy of the different floors throughout the entire life of the building. These engineering plans when completed form the basis for the architectural plans and for the specifications covering the requirements for engineering, manufacturing and installing the central office equipment.

Protection against fire is, of course, one of the most important considerations involved in planning our buildings. Next to the safety of the personnel, continuity of service is the main objective. The most approved fire resisting devices such as metal and wire glass windows, hollow steel doors, extra strong partitions enclosing shafts and exits, and rolling steel shutters for openings facing hazardous exposures are employed. In addition, very complete fire fighting appliances are provided in all buildings.

Finally, in connection with the architectural phases, whether the building be in a small community or in a metropolitan centre,

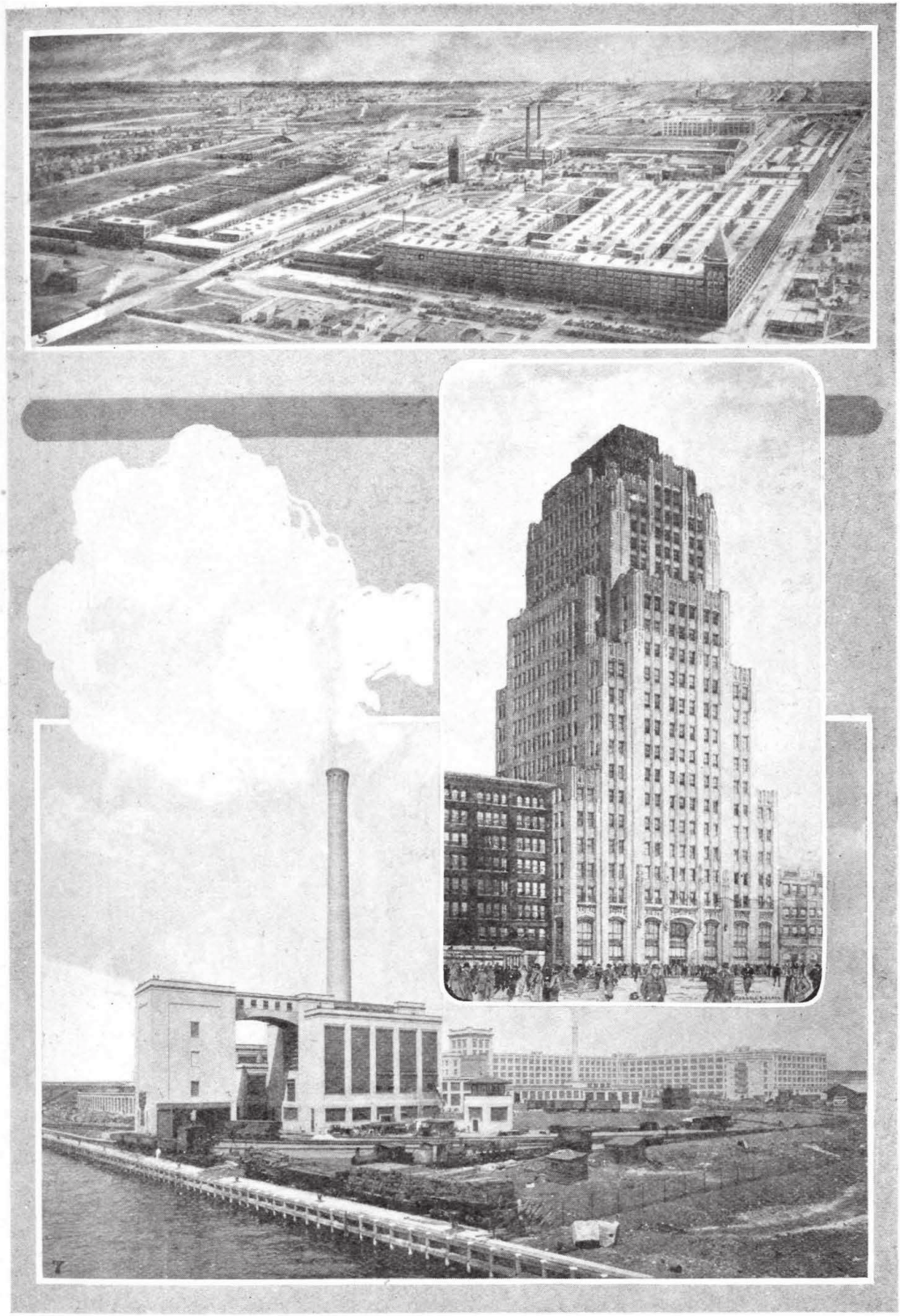


FIG. 5.—THE HAWTHORNE (ILL.) PLANT OF THE WESTERN ELECTRIC COMPANY.
FIG. 6.—THE NEW ADMINISTRATION BUILDING IN CLEVELAND OF THE OHIO BELL TELEPHONE COMPANY.
FIG. 7.—THE KEARNEY (N. J.) PLANT OF THE WESTERN ELECTRIC COMPANY.

constantly increasing consideration is given to the desirability of having it display individuality and character consistent with its surroundings. Also, where landscaping is appropriate, careful attention is given to beautifying the grounds. Our buildings from the very nature of the telephone problems must be more or less centrally located with respect to the subscribers served, and many of them therefore, must be placed in residential areas. In these cases in particular, stress is laid on insuring that the building and grounds be appropriate to their surroundings.

Figs. **2**, **3** and **4** illustrate typical central office buildings such as are provided in large and small communities throughout the System.

Up to this point the discussion has centered around the buildings housing the operating activities. The manufacturing branch of the System—the Western Electric Company—presents another interesting phase of this housing problem. The requirements to be met here are, of course, of a substantially different character from those of the operating companies.

Moving about 1878 from La Salle Street, to larger quarters in Kinzie Street, Chicago, the personnel employed by the firm which later became the Western Electric Company consisted of perhaps 100 people occupying about 12,000 square feet of floor space. In a span of little less than 50 years, this has expanded to the enormous manufacturing plants at Hawthorne and Kearny and to the 34 distributing warehouses located strategetically throughout the country and engaged solely in the manufacture and supply of telephone facilities.

Fig. **5** shows a general view of the Hawthorne works which contain close to 4,000,000 square feet of floor space and provide working space for some 41,000 employees.

The existing construction at Kearny already develops close to 800,000 square feet of space and the coming Fall will see completed and occupied something over 1,000,000 square feet in the aggregate. Approximately 2600 employees are now engaged at Kearny. Fig. **7** shows the development of the Kearny works.

Also besides these tremendous areas at Hawthorne and Kearny, the manufacturing department occupies at other localities a little more than 600,000 square feet, substantially all of which is leased space. This space was taken over as the direct result of the Western Electric Company's extensive participation in the activities brought about by the European War and according to the present plans will all be replaced by new space at Kearny.

It is of interest to note that the 34 distributing warehouses contain in themselves 1,800,000 square feet of floor space. Each distributing house must, of course, be located suitably with respect to the center of distribution for telephone supplies and also

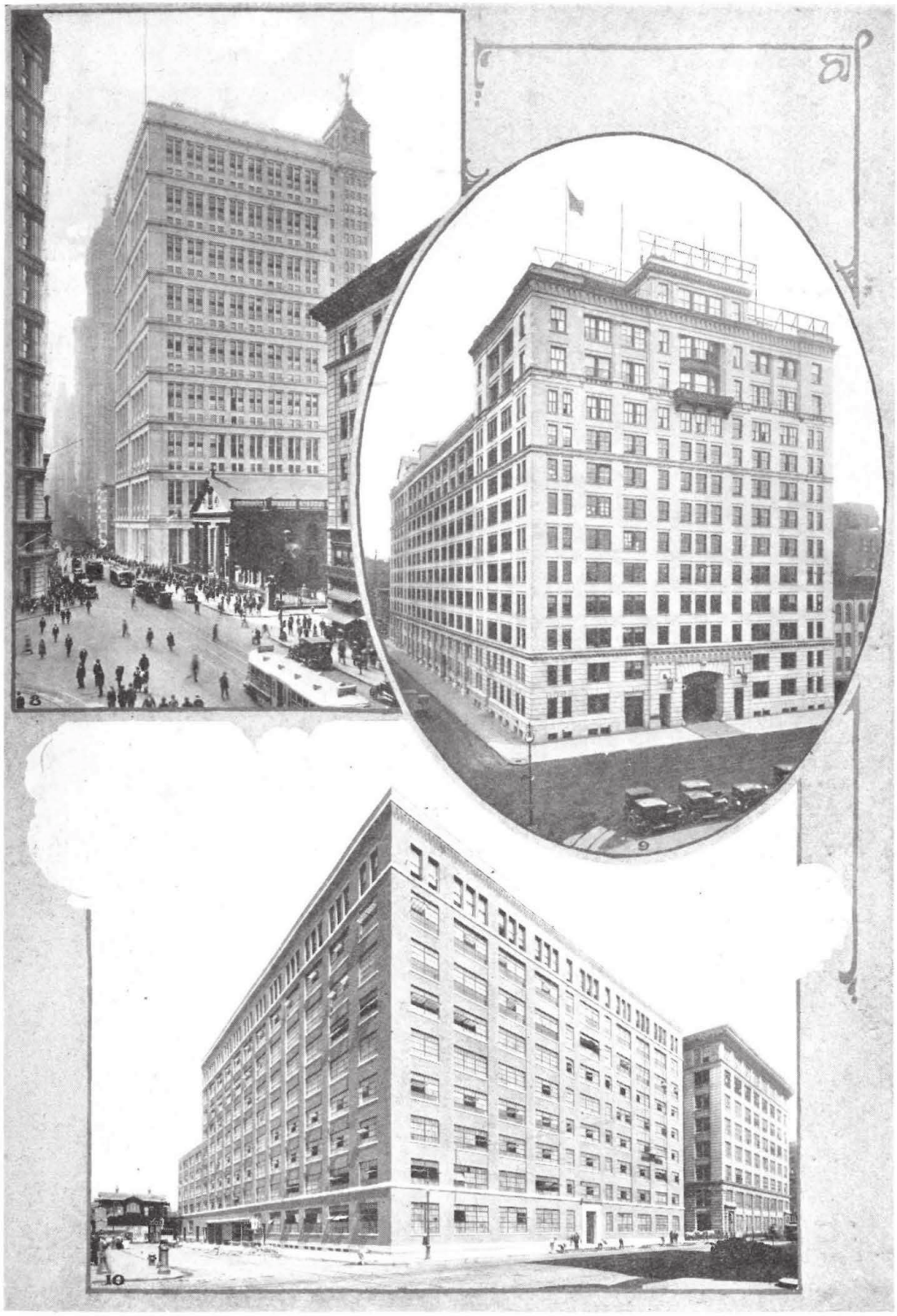


FIG. 8.—THE HEADQUARTERS OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY AT 195 BROADWAY, NEW YORK.
FIG. 9.—THE BELL TELEPHONE LABORATORIES, NEW YORK.
FIG. 10.—A LARGE EASTERN DISTRIBUTING WAREHOUSE FOR TELEPHONE SUPPLIES.

from the standpoint of satisfactory transportation facilities. Fig. 10 shows one of the large eastern distributing houses.

In a word, the Western Electric Company to-day occupies in round numbers over 7,400,000 square feet of floor space, 75 per cent. of which is in company-owned buildings. Area figures in the Western Electric case must be almost meaningless if expressed only in square feet. A better appreciation can be obtained of what it means to house so vast an enterprise as the manufacturing and distributing branches of the Bell System when it is pointed out that the area comprised by this 7,400,000 square feet is equivalent to 170 acres.

When it is considered that the housing problems of the Western Electric Company range from foundries and iron working shops on the one hand to shops for the turning out of the most intricate precision instruments on the other, and comprise wood, fabric and wire working mills, it will be seen how wide and comprehensive must be the scope of these housing activities.

Factory planning as practised to-day by the Western Electric building engineers was unknown when their problems first became apparent, and their solution, allied with the advance in the art of telephony are a most valuable contribution to the science of factory engineering in general.

Still another phase of the housing problem of the System is that of providing space for administrative, research and laboratory purposes.

The Bell Telephone Laboratories building at West and Bethune Streets, New York, is shown in Fig. 9. Within the past year the original structure has been increased in size to take care of the increasing volume of research work. The building as it stands contains about 600,000 square feet of floor space devoted wholly to laboratory purposes and to housing the more than 3,500 scientists, engineers and assistants who are engaged in every phase of the development and research work. Also the building houses a most complete and valuable display of historical telephone apparatus, and has in the top story an auditorium with a seating capacity of about 1000. It is interesting to compare all this with the few hundred square feet of floor space which sufficed for Dr. Bell and his one assistant in Court Street, Boston.

The headquarters building of the American Telephone and Telegraph Company at 195 and 205 Broadway, New York, is shown in Fig. 8. This building is 26 stories high and contains roughly 600,000 square feet of floor space, about 500,000 of which are used by the 5,000 or so telephone employees engaged in the general departments of the American Company and the Western Electric Company.

Many other large buildings are required for the administrative

FIG. 11.—THE NEW ADMINISTRATION BUILDING IN NEW YORK OF THE NEW YORK TELEPHONE COMPANY.
FIG. 12.—THE NEW ADMINISTRATION BUILDING IN ST. LOUIS FOR THE SOUTHWESTERN BELL TELEPHONE SYSTEM.
FIG. 13.—THE NEW ADMINISTRATION BUILDING IN SAN FRANCISCO OF THE PACIFIC TELEPHONE AND TELEGRAPH COMPANY.

staffs of the operating companies. The last year has seen the completion or start of four outstanding Bell System structures located in New York, Cleveland, St. Louis and San Francisco. These buildings which are shown in Figs. **11**, **6**, **12** and **13**, represent an investment aggregating close to $35,000,000. The combined productive floor area is roundly 1,600,000 square feet—which is about 37 acres. Their aggregate volume is close to 40,000,000 cubic feet—or about the volume which would be developed by a pyramid 450 feet square at the base and extending upward somewhat beyond the height of the Washington monument. The size of these structures does not, of course, reflect a desire for large buildings, but rather indicates the vastness of the enterprise. An appreciation of this is obtained when it is realised that the aggregate plant investment of the four companies whose administrative staffs are housed in these buildings is over a billion dollars and that space is also available to house central office switchboards for some 300,000 stations. This is equivalent to the number of telephones in a city having a population of 1,500,000.

These four buildings represent different treatments of the new architectural design, developed in America to give beauty and distinction to the so-called skyscraper.

Where a many-storied building is necessary in order to utilize to the best advantage valuable land, it has been found in this country that such a building can be made so architecturally fine that it becomes an object of pride to the community as a whole. Such buildings not only are attractive in themselves, but they also exemplify the high ideals of the Bell System.

Telephone building history from the first New Haven office with its few hundred feet of leased space to these tremendous office and equipment buildings of to-day, contains an absorbing record of the development of the housing phase of the System's activities. The great structures shown are striking examples of the way in which the Bell System has grown in this relatively brief span of fifty years.

H. P. CHARLESWORTH.

EDINBURGH'S AUTOMATIC TELEPHONE EXCHANGES.

By H. W. Dipple, A.M.I.E.E.

The conversion of the central portion of the Edinburgh Exchange area and the transfer of 11,583 subscribers and 1,153 junctions and trunks to automatic working on 3rd October, 1926, represents the largest task of this kind that the Engineering Department of the British Post Office has yet undertaken.

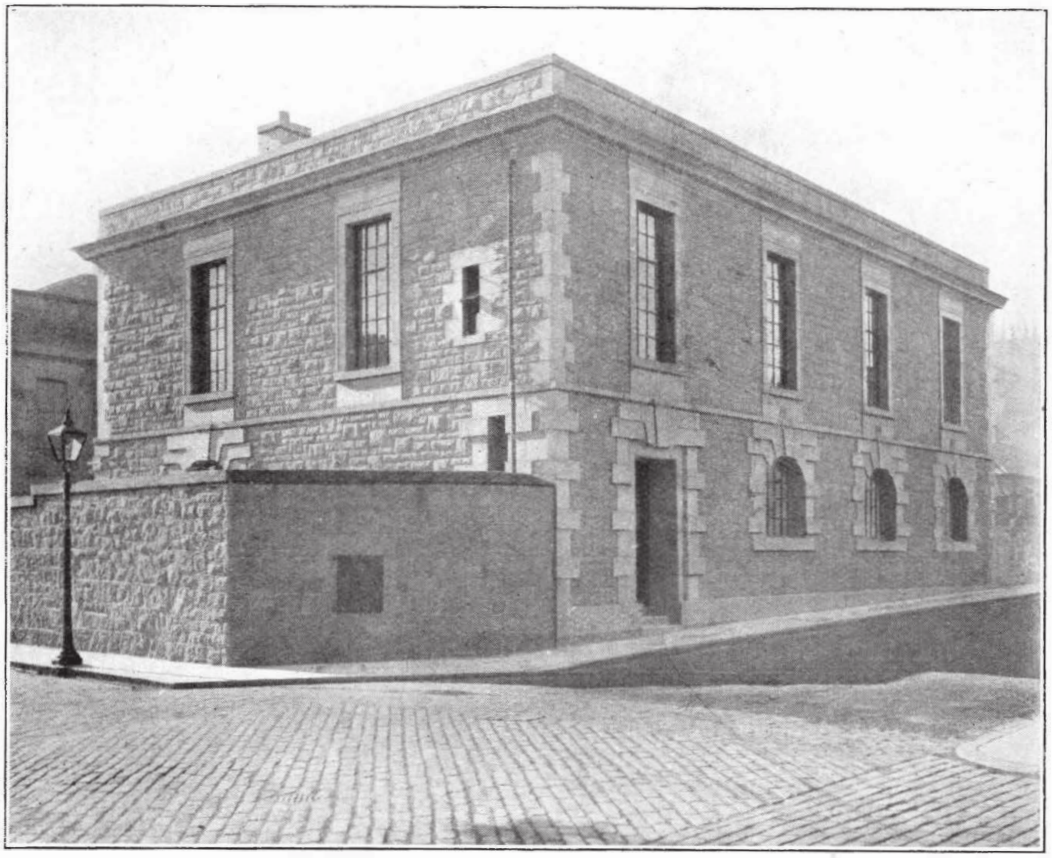


Fig. 1.—Newington Auto. Exchange, Edinburgh.

The Edinburgh area was served originally by a 10,000 line No. 1 C.B. Exchange at Central, with sub-exchanges at Colinton, Corstorphine, Davidsons Mains, Granton, Portobello and Leith. About 3 years ago a 2,000 line relief exchange named Museum was opened in the Central building to carry development until the automatic equipment was ready for use.

Before automatic working was decided upon a complete study of the area was made, and it was found economical to relieve the Central building by opening satellite exchanges at Newington,

Morningside and Murrayfield. After the transfer was effected, the subscribers' lines were re-distributed as follows:—

Central	6,778
Newington	1,724
Morningside	1,832
Murrayfield	1,249
Total	11,583 lines

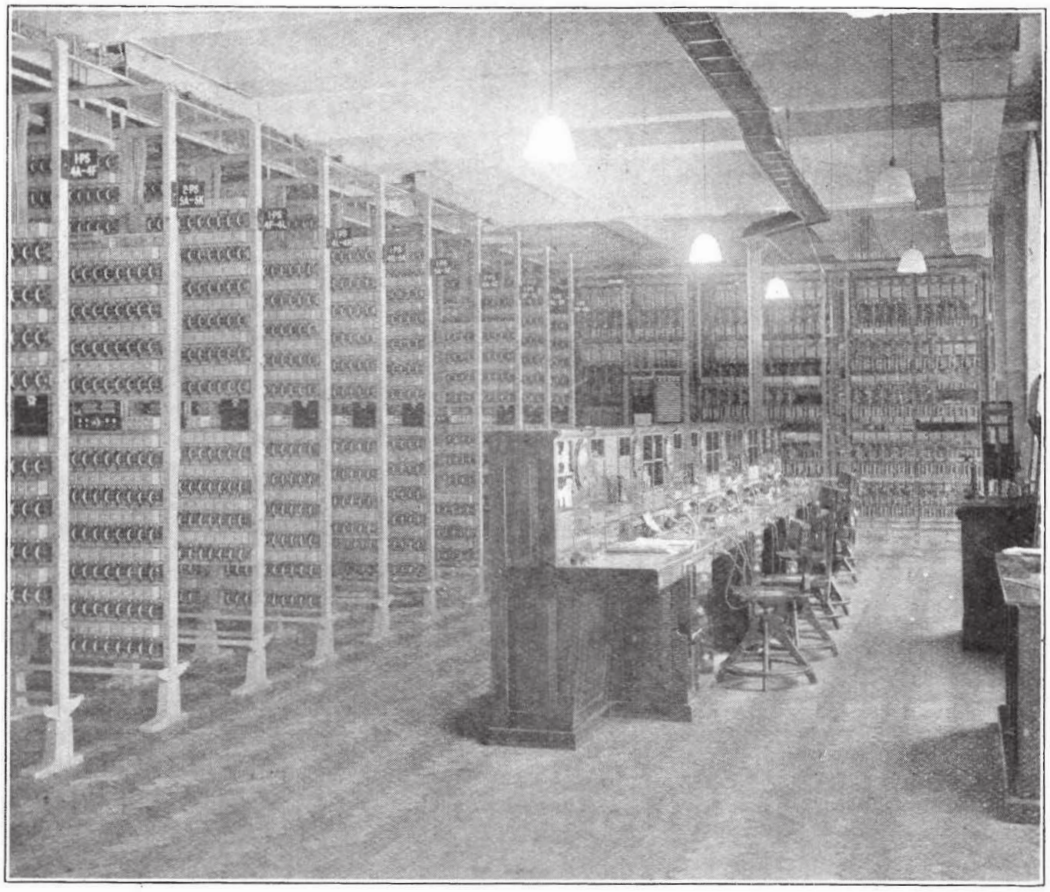


FIG. 2.—EDINBURGH CENTRAL EXCHANGE. 8 POSITION TEST DESK AND PRESELECTOR RACKS.

New buildings were provided for the satellites, of which that for Newington, shown in Fig. 1, is typical.

The original arrangement of the Central Exchange building was:—

Ground floor ...	District Manager's Office.
First ,, ...	Staff dining rooms, Engineers' offices, etc.
Second ,, ...	Apparatus Room for Central & Museum, Traffic offices, etc.
Third ,, ...	Central and Museum Exchanges.

After careful investigation it was decided that by removing the District Manager to other quarters, sufficient equipment could be installed on the ground floor to accommodate the subscribers' lines remaining on Central after the re-distribution, and to provide for development until further plant could be installed when the second floor became available. It was also decided to instal a temporary manual board on the second floor in rooms formerly occupied by the Traffic Staff. The actual equipment installed on the ground floor is 8,300 lines, together with the 1st selectors for satellites, and for manual exchanges dialling in to the Edinburgh

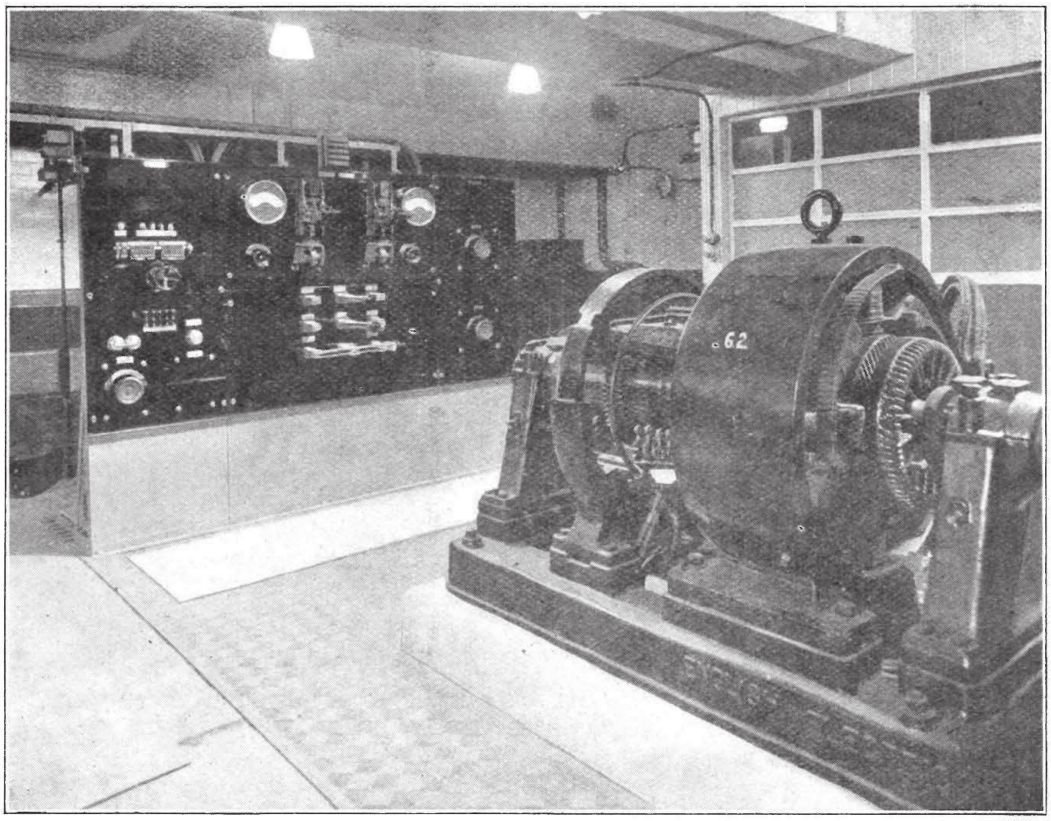


FIG. 3.—EDINBURGH CENTRAL EXCHANGE. CHARGING GENERATOR AND POWER BOARD.

area. Under this scheme the allocation of the building is as follows:—

Basement	...	Power plant and batteries.
Ground floor	...	Automatic plant, 1st Unit of 8,300 lines.
First ,,	...	Staff dining rooms and Repeater Station, etc.
Second ,,	...	Automatic plant, 2nd Unit.
Third ,,	...	Manual board (permanent) and operators' quarters.

Owing to greatly increased development, it is probable that the whole of the third floor will be required for the Manual Board, the operators' quarters being provided in an adjacent building.

The initial and ultimate equipment at the exchanges is as follows:—

	Initial.	*Ultimate.*
Central Unit No. 1	8,300	8,300
Unit No. 2	1,000	6,300
Morningside	2,500	4,400
Newington	2,100	3,600
Murrayfield	1,700	2,900

It is proposed to convert the sub-exchanges in the area to automatic working during the next few years. In the meantime, however, automatic subscribers obtain direct access to these exchanges by dialling special numbers. The initial and ultimate numbering schemes for the area are as follows:—

	Initial.	*Ultimate.*
Central 1st Unit ...	20,000—29,299	20,000—29,299
2nd Unit ...	30,000—30,999	30,000—36,299
Newington	41,000—43,099	41,000—44,599
Morningside	51,000—53,499	51,000—55,399
Murrayfield	61,000—62,699	61,000—63,899
Leith	7	71,000—73,499
Portobello	82	81,000—81,899
Granton	84	83,000—83,799
Corstorphine	85	85,000—85,499
Colinton	88	86,000—86,599
Davidsons Mains ...	89	87,000—87,499

The numbering scheme for the sub-exchanges was arranged as far as possible to allow of the level used for the dialling-out code to be made spare and connected to the Number Unobtainable Tone circuit, when an exchange is converted to automatic working.

The automatic plant installed in the area is Siemens No. 16 type equipment, which is now too well known to need any special comment. It is interesting to note, however, that the satellites are equipped with Discriminating Repeaters and Selectors. With each Repeater is associated a Junction Finder and a Selector Finder. When a subscriber calls, he is thus connected to an outgoing junction to the 1st Selectors at Central and to a Discriminating Selector. When the digits dialled determine the call to be local, the junction is released and becomes free to another calling subscriber. If the call is not local, the Discriminator Selector is released and the call completed over the junction to Central. Discrimination is effected on the first digit of the satellite number, *e.g.*, "4" in the case of Newington.

The circuit arrangements of the Discriminator circuits are those peculiar to Siemens No. 16 system, but the facilities provided are practically identical with those of the A.T.M. Co.'s Switching Selector Repeater at Leeds, which was described in the April, 1926, issue of this Journal.

Fig. **2** gives a general view of the Test Desks, 1st Preselectors, and 1st Selectors at Central.

Fig. **3** Charging Machine and Power Board at Central.

Fig. **4** 1st Preselectors, Incoming and Local 3rd Selectors, Newington.

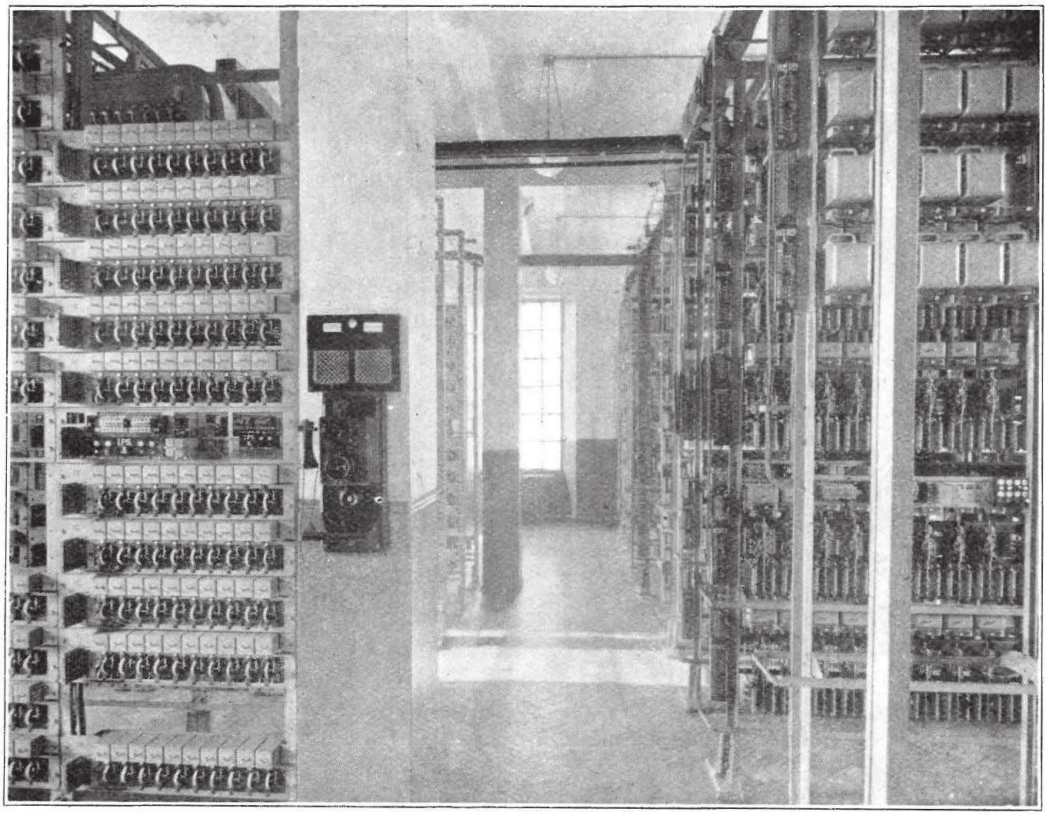


FIG. **4**.—GENERAL VIEW OF SWITCH ROOM, NEWINGTON AUTO. EXCHANGE.

Fig. **5** General View, Morningside.

Fig. **6** 1st Preselectors, Murrayfield.

The transfer was effected at 5 minutes past midnight on Sunday, October 3rd, 1926, traffic at that time being very light. Cutting out took place in the old apparatus room, some 42,000 heat coils being withdrawn in three minutes. The withdrawal of the wedges from the protectors on the new Main Frames was carried out rather more leisurely in order to avoid trouble due

to displaced carbons, but the total time occupied in the transfer from first to last was approximately only 9¼ minutes. Immediately after the transfer a total of 81 P.G.'s at 1st Selectors was noticed, and within 10 minutes this number had fallen to 35.

Testing of subscribers lines began immediately, and the result of the test showed a total of 205 faults, representing 1.7% of the total number of lines. Approximately 50 of these were subsequently found to be ordinary day-to-day maintenance troubles, so that the percentage of faults arising out of the transfer was actually 1.3%. In view of the large number of circuits to be dealt with, this result cannot be regarded as other than excellent.

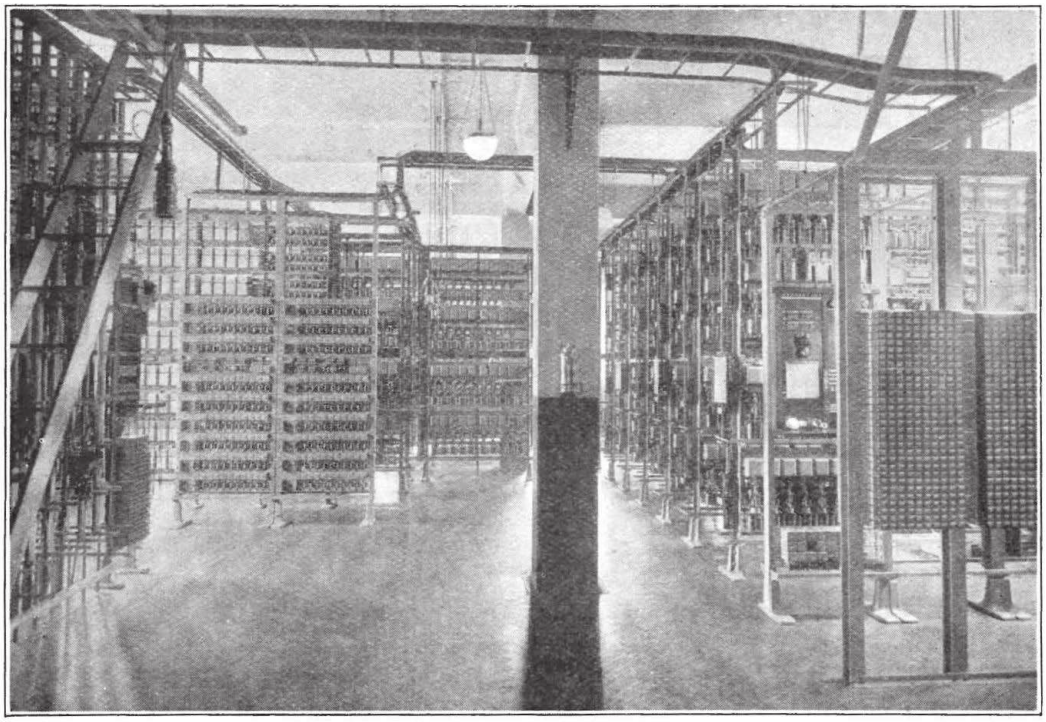


FIG. 5.—GENERAL VIEW OF SWITCH ROOM, MORNINGSIDE AUTO. EXCHANGE.

Telephone Engineers who have had experience of transfers will be able to visulize the careful organisation required for the vast amount of work involved in testing, and the detailed work in the keeping of records of lines, removals, ceases, etc., where nearly 12,000 subscribers lines are concerned. They will, therefore, be quick to appreciate the excellence of the transfer and the hard work and enthusiasm of the Edinburgh Engineering force in bringing about such a splendid result. An idea of the amount of testing work required in a large automatic area will be gained from the following summary of plant in the Edinburgh area:—

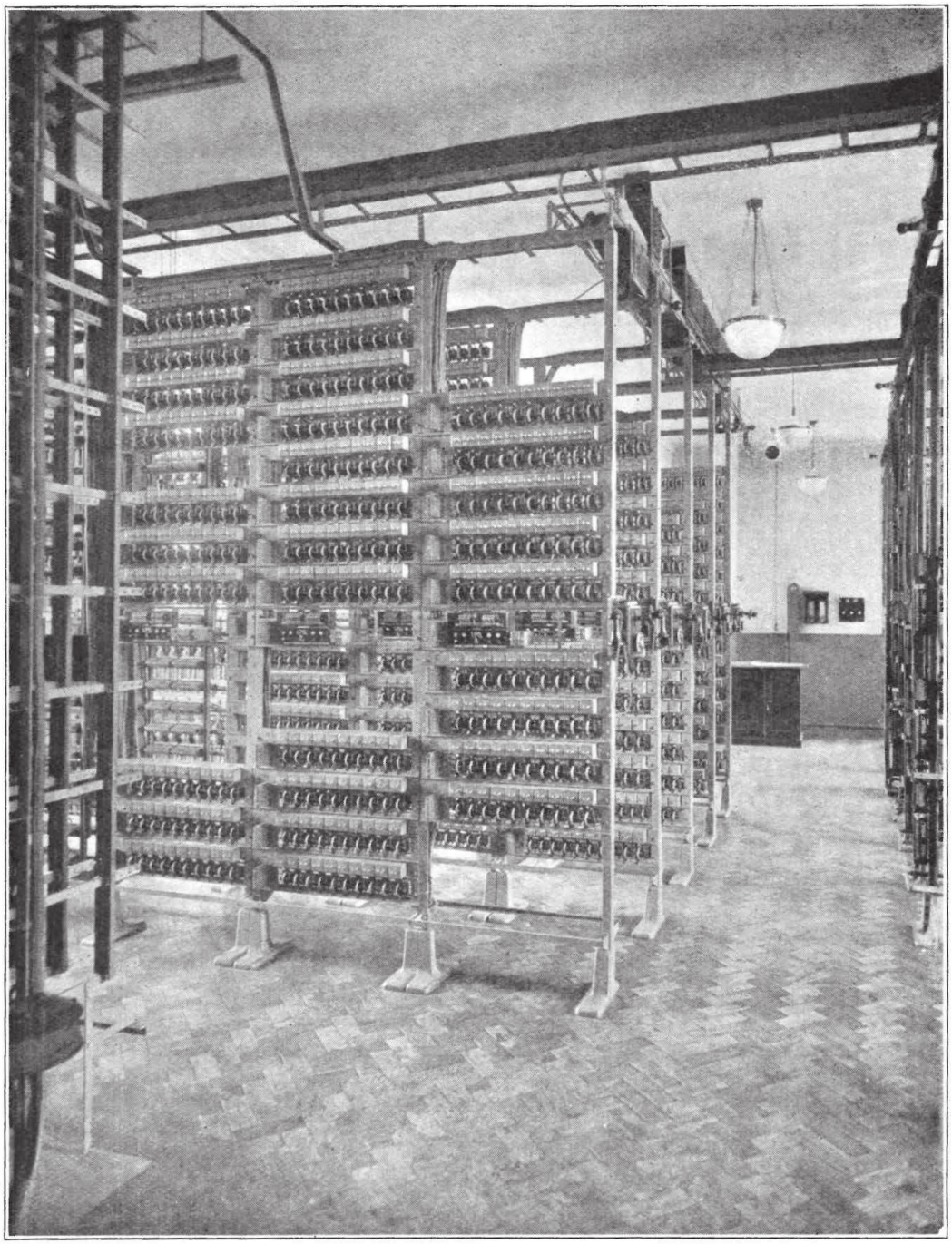


FIG. 6.—MURRAYFIELD AUTO. EXCHANGE. FIRST PRESELECTOR RACKS.

1st Preselectors	...	...	14,640
2nd ,,	...	...	1,920
1st Selectors	...	...	1,328
2nd ,,	...	...	1,196
3rd ,,	...	...	1,487
Final ,,	...	...	1,871

Discriminating Selectors	...	76
,, Repeaters	...	280
Miscellaneous Switches	...	335
Subscribers Meters ...	...	15,600

On the day following the transfer, the traffic flowed very smoothly, very little traffic congestion occurring, and the subscribers very quickly settled down to the new method of working. There seems no doubt that the conversion from C.B. working was a contributing factor to this, as it was possible of course to recover the existing telephones before the transfer.

The temporary Manual Board consists of:—

1 Cordless B position with Key Sender,
7 Trunk Signalling positions,
2 Special control ,,
5 Jack-ended junction ,,
15 A positions for "o" level calls,
1 Service P.B.X. position.
1 12 position Monitors Desk.

The permanent Manual Board will be installed in the old "Central" switchroom as soon as the old equipment has been recovered and the room prepared for the new plant.

The second Automatic Unit of 1,000 lines initial equipment will be installed in the old apparatus room when the old plant has been recovered and the necessary structural alterations made.

A Centralized Service Observation equipment will be installed also. This consists of a 2-position Desk at Central with equipment for observing service on 50 Central subscribers and on 25 subscribers at each of the Satellite Exchanges. With this latter equipment, one junction circuit between the distant exchange and the Service Observation Desk will allow the service of 25 subscribers to be observed.

Thanks are due to Messrs. Siemens Bros. & Co., Ltd., for the photographs with which this article is illustrated.

OPERATING TIME LAG OF RELAYS.

In Automatic Telephony the need of a more thorough knowledge of the principles governing relays and their operation is becoming more and more evident. Hitherto, a relay has been regarded chiefly as an electro-magnet which, when energised, was capable of opening or closing certain contacts, and the only information that was considered necessary was a knowledge of the limiting values of current which would cause it to operate or release. The ever-increasing complexity of automatic circuits, caused by the necessity of meeting more and more stringent requirements, has compelled circuit designers to ask for relays that function within fixed time limits as well as within fixed current limits. Hence it is that a knowledge of the operating and releasing lags of relays has become of primary importance. It should be remarked, however, that this development must be accompanied by increased accuracy of maintenance, since the time elements of a relay depend very much upon its adjustment and one of the problems that must be solved is a method of manufacturing and maintaining relays within close limits, both as regards operating currents and operating times.

The following extract from a paper by S. Raybould entitled, "The measurement of operating and releasing lags and relays by means of a Ballistic Galvanometer" (Annales des Postes, Télégraphs et Téléphones," March, 1926), is, therefore, of considerable interest:—

Certain electro-mechanical means can be used to determine the time periods of a relay, but unfortunately they necessitate the use of apparatus which is rarely available in a laboratory. For example, a Baudot distributor can be used. From one of the contacts (A) of the distributor, a current is completed for the winding of the relay under consideration, the operation of which closes the circuit of a telephone receiver connected to a moving contact (B). By displacing this contact one can find the point at which the relay operates. By dividing the arc which separates the contacts (A) and (B) by the angular speed of the distributor, the operating lag of the relay is found. Investigations have, however, led to the discovery of a simple and practical method of measuring time periods which gives very satisfactory results. This method, which can be varied to meet the particular case, is based on the following principles: the charge q received in a time t by a condenser of capacity C placed in a circuit of resistance R is given by the equation

$$q = Q\,(1 - \epsilon^{-\frac{t}{CR}}) \qquad \ldots\ldots(1)$$

If a scheme be devised in which the condenser is partially charged during the time which it is desired to measure, the measurement of q will enable the time to be calculated.

It may be necessary to know either the operating or the releasing lag of a relay, depending on the functions which in practice it will have to perform. The method will be explained by describing two cases.

Case 1.—To determine the time that elapses between the closing of the current in the winding of relay A (Fig. 1) and the instant at which the make contact is closed, it is necessary to have a constant voltage E, a well insulated condenser of capacity C, a high resistance r, and a ballistic galvanometer of resistance g. The connections are shown in Fig. 1. If key M be closed while keys N

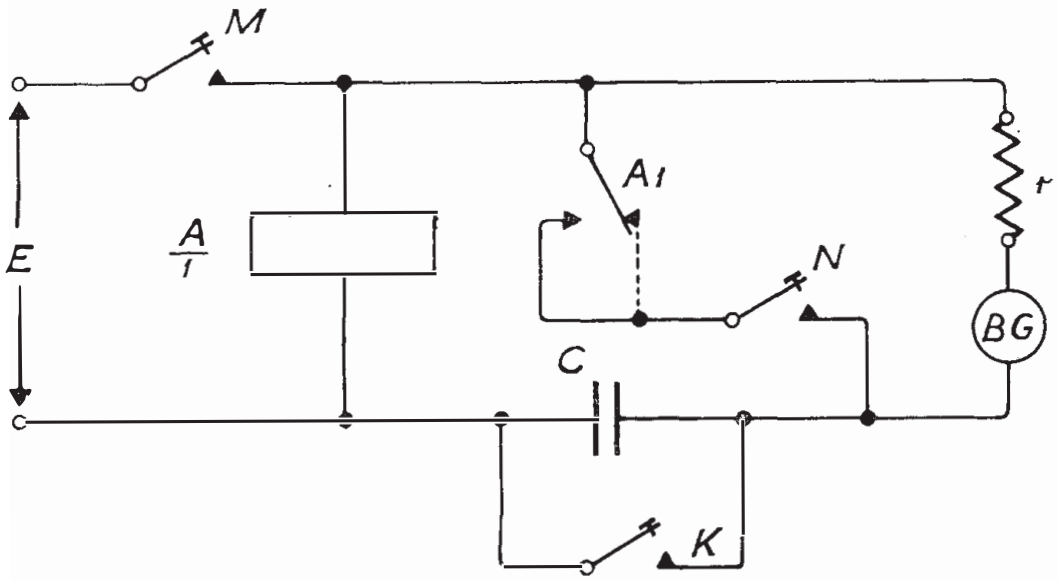


FIG. 1.

and K are open the ballistic galvanometer would give a deflection θ, which is proportional to the charge received by the condenser C. This charge is

$$Q = CE = K\theta_1$$

This is the ordinary equation of the galvanometer from which the constant K can be found. It will be referred to later. The following operations are then performed:—

(1) Key M is opened.
(2) Key N is closed.
(3) Key K is used to discharge the condenser, the discharge being shown by the return of the ballistic galvanometer to zero.
(4) Key M is closed.

The condenser is charged and the ballistic galvanometer gives a deflection θ_2 proportional to the charge that C receives during the time that elapses between the closure of M and the closure of the operated contact of the relay. This charge has a value

$$q = K\theta_2$$

Let us suppose that the condenser used has a very high internal resistance and that consequently its conductance is negligible. The resistance of the circuit is, therefore :—

$$R = r + g$$

as we have already seen

$$q = Q\left(1 - \epsilon^{-\frac{t}{CR}}\right)$$

from which we have

$$\frac{t}{CR} = \log_e \frac{Q}{Q - q}$$

and

$$t = CR \log_e \frac{Q}{Q - q}$$

by replacing Q and q by their value in terms of deflection

$$t = CR \log_e \frac{\theta_1}{\theta_1 - \theta_2}$$

The time will be expressed in seconds if C is in farads and R is in ohms.

By connecting the "make" and "break" springs (shown dotted in Fig. 1) the period of disconnection of the moving spring can be measured and by substracting this value from the result already obtained the electro-magnetic retardation of the relay can be found.

Case 2.—To determine the time which elapses between the instant at which the circuit of relay A is opened and the instant at which its armature returns to normal (Fig. 2).

In this case it is necessary to use an extra relay of which the operating lag has previously been measured.

The actual measurements in this case are made in exactly the same manner as in the first case, but it will be necessary to subtract from the result the delay introduced by the auxiliary relay before the required time period can be found.

The measurement can be simplified by the use of a well adjusted Baudot relay for the auxiliary relay, the lag which it introduces being usually less than one millisecond and therefore in most cases it can be neglected.

Accuracy of Measurement.—It can be shown that for maximum accuracy the following conditions should be aimed at—

$$T = C.R.$$

If this condition holds good, approximately an accuracy of about 3% can be obtained.

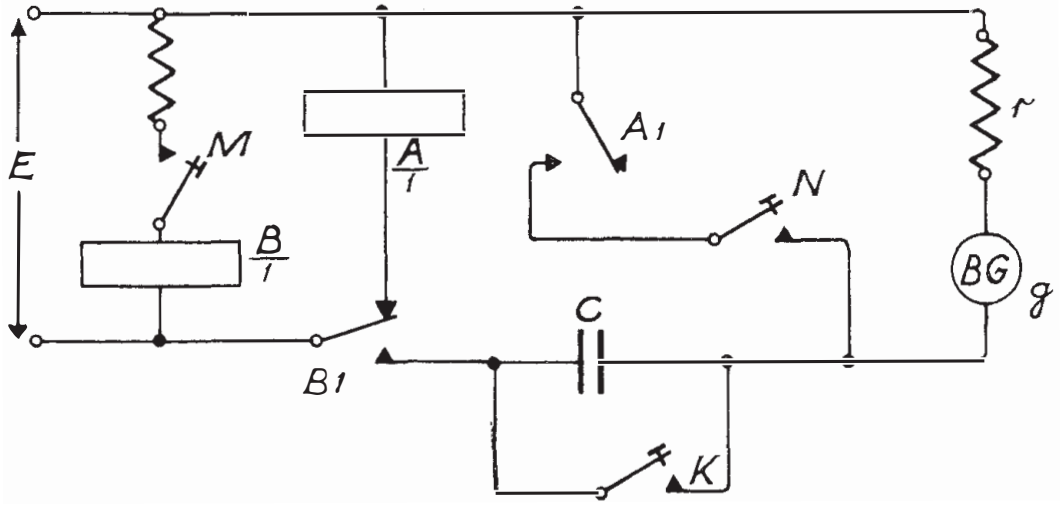


FIG. 2.

In the particular case of a relay possessing an operating period equal to CR seconds, the ballistic galvanometer gives a deflection

$$\theta_2 = 0.63 \times \theta_1$$

By using a variable resistance "r," this peculiarity can be made use of, for if by means of several measurements, the value of r can be adjusted such that

$$\theta_2 = 0.63\,\theta_1$$

Then $$t = C.r.$$

By this means the operating time can be obtained by direct reading.

F. I. RAY.

STRENGTH OF FLOORS IN TELEPHONE EXCHANGES.

By Capt. H. Hill, B.Sc., M.I.E.E.

In buildings specially erected for Telephone Exchange purposes, the floors of rooms planned for equipment are now usually of filler joist construction. Concrete slabs reinforced with rods or mesh are not used because of difficulty in cutting cable holes without unduly weakening the strength of the slab. Should the time ever arrive when the exact location of the cable holes can be determined before the floors are constructed this difficulty would not arise.

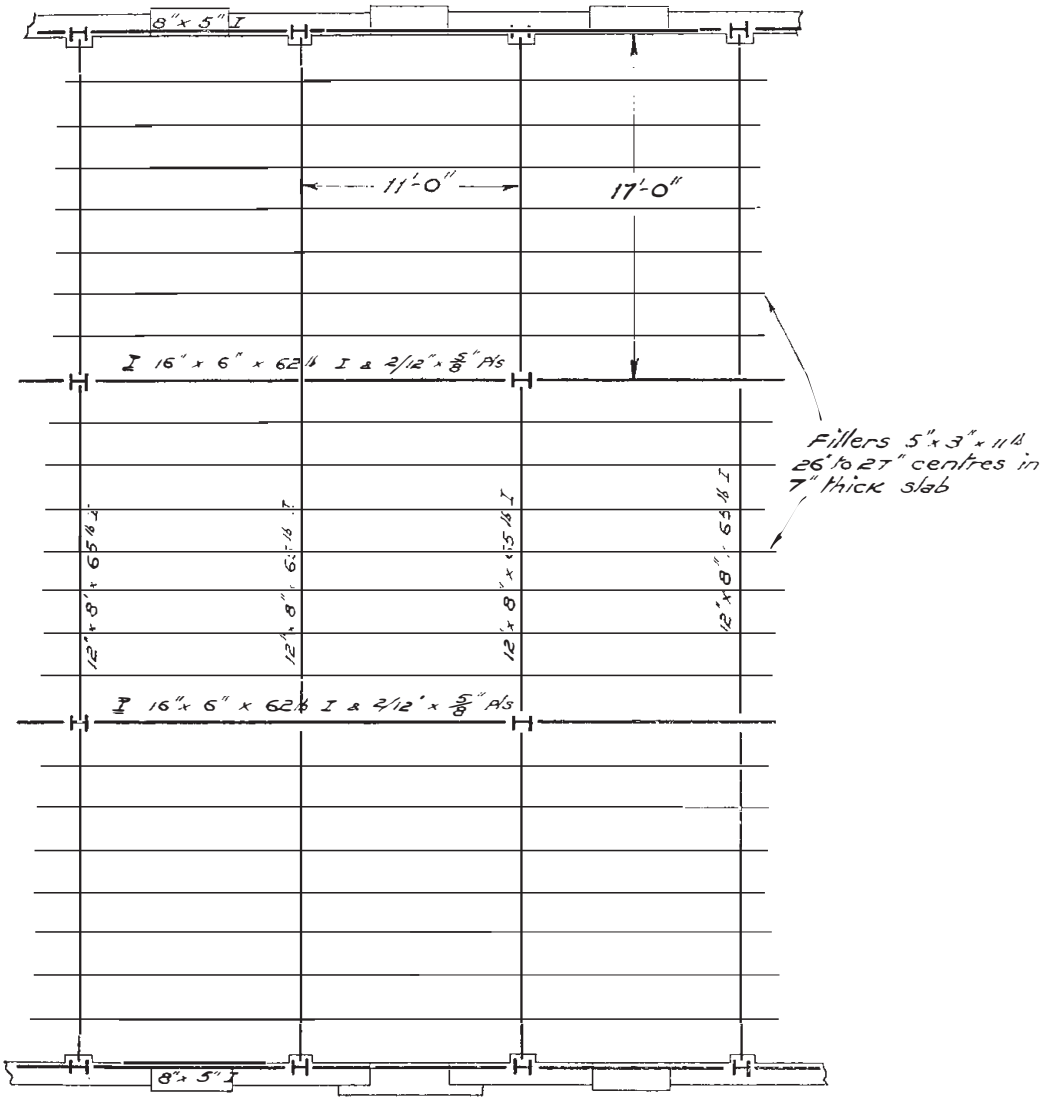

8" x 5" I
11'-0"
17'-0"
16" x 6" x 62½ I @ 2/12" x ⅝" Pls
Fillers 5" x 3" x 11½
26" to 27" centres in
7" thick slab
12" x 8" x 65½ I
12" x 8" x 65½ I
12" x 8" x 65½ I
12" x 8" x 65½ I
16" x 6" x 62½ I @ 2/12" x ⅝" Pls
8" x 5" I

Fig. 1.

A plan of the steel work in a portion of a typical floor of filler joist construction is given in Fig. 1.

The method adopted to express clearly and simply the strength of any floor is to state that it is capable of carrying a certain uniformly distributed load per square foot. A floor having been designed to carry such a load, the question often arises as to the extent to which loads which are not uniformly distributed can be applied to the floor without overstressing it.

For example, let us suppose that in a room of 300 square feet area, with the floor designed to carry 150 lbs. per square foot, it be proposed to instal apparatus racks weighing in all 14,000 lbs., and that this load be applied to the floor through 12 footings having a total floor bearing surface of about 350 square ins.

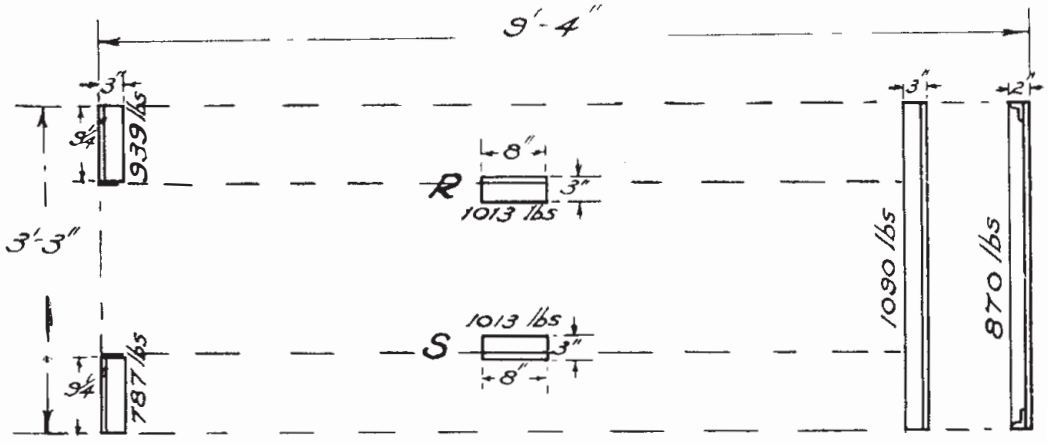


Fig. 2.

The average load on the floor is only $\frac{14000}{300}$ = 46 2/3lbs. per square foot, but it by no means follows that the floor will be strong enough owing to the fact that the manner of application of the load may cause greater stresses in some of the steel than would a load of 150 lbs. per square foot uniformly distributed. The concentrated load on the floor immediately beneath the footings is at the rate of $\frac{14000}{350} \times \frac{144}{1}$ = 576 lbs. per square foot. A floor designed for a uniformly distributed load of 150 lbs. per square foot might quite safely carry such concentrated loads provided the footings are large enough to keep the shearing stresses in the floor within safe limits. With all footings designed for apparatus racks and with the loads which they carry, it may be taken for granted that as the loading increases, a floor will first become overstressed due to the deflection of the steel while the shearing stresses are still within safe limits. It follows, therefore, that concentrated loads in the particular problem under review need only be considered in

relation to the bending moments which they produce in the steel. It will now be gathered that neither the average loading, 46 2/3lbs. per square foot in the example above, nor the degree of concentration, 576 lbs. per square foot, is much guide in itself in determining whether a floor will be strong enough to carry apparatus.

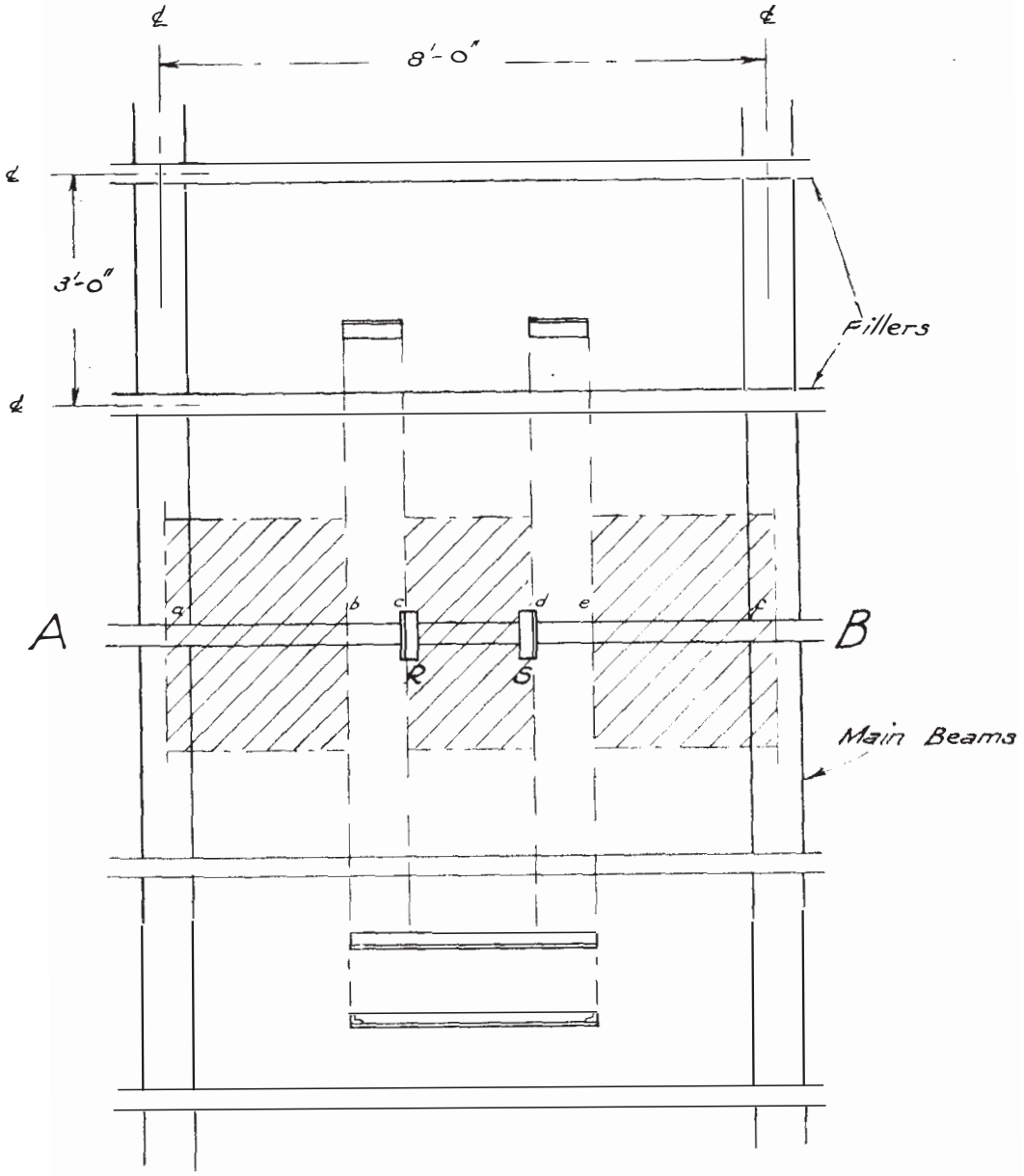


FIG. 3.

An example showing the method of determining the strength of floor necessary to carry apparatus racks may serve in clarifying ideas on the subject. A typical selector rack in an automatic exchange will be taken for illustration. Fig. **2** shows the floor bearing surfaces and the loads transmitted to the floor by the footings of the rack supplied by one particular contractor.

In the design of the rack it is provided that the load taken by each rack footing is well distributed over its bearing surface and that the area is sufficient to keep the shearing stresses in the floor within safe limits.

It would be impracticable to place automatic apparatus racks in any standard position relative to the steel in the floor and the floor must therefore be designed to carry the racks on the assumption that they may be placed in the position which imposes greatest stresses. In the case of the Selector Board a study of the stresses caused by various arrangements shows that the worst position is that in which loads R and S (Fig. **2**) lie directly over and symmetrical about the centre of a filler joist, as shown in Fig. **3**.

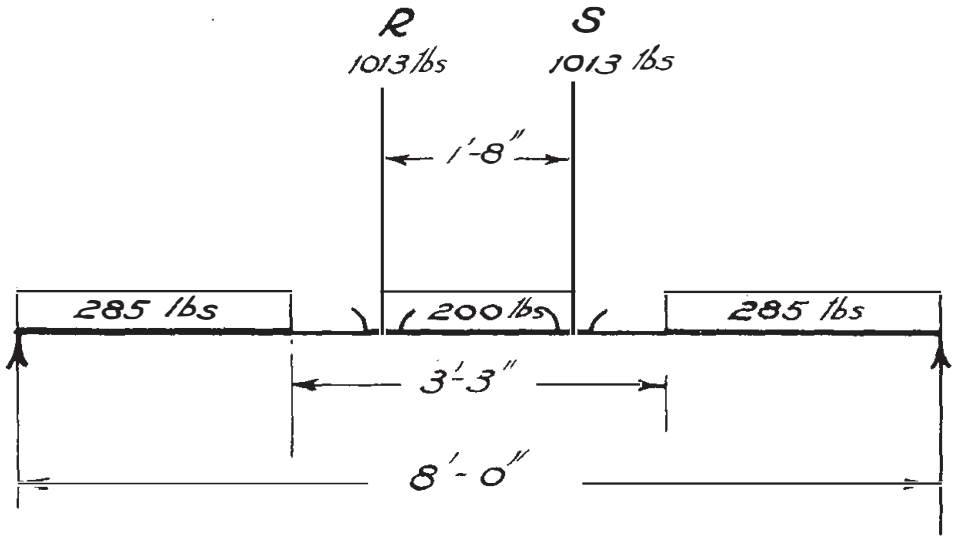


FIG. **4**.

As our problem is to find the equivalent uniformly distributed load it will be clear that the length of the filler joists and their distance apart will affect the result. If therefore we wish the result to cover all possible conditions we must again choose the worst case and in the following calculations it is assumed that this will be given by 8 feet fillers at 3 feet centres. The filler carrying the heaviest load will be AB in Fig. **3**, and its load will consist of the concentrated loads R and S and the proper proportion of the gangway loading between *a* and *b*, *c* and *d*, *e* and *f*, shown cross hatched. The filler is therefore loaded as shown in Fig. **4**. The two concentrated loads are due to the weight applied through the rack footings and the distributed loads to the allowance for gangway loading, which is taken as 40 lbs. per square foot.

The Maximum Bending Moment on the filler works out to 3910 ft. lbs. approximately.

The equivalent uniformly distributed load "ω" per foot run is given by

$$\frac{\omega l^2}{8} = 3910$$

$$\omega = \frac{3910 \times 8}{8^2} = 489 \text{ lbs.}$$

As the fillers are spaced 3 feet apart this reduces to $\frac{489}{3} = 163$ lbs. per square foot, which gives the uniformly distributed superimposed load per square foot for which a floor would have to be designed to provide for the possibility of placing selector boards in any position.

Similar consideration must be given to all other racks liable to be used in an automatic exchange and suitable additions made for cable runs before a standard strength can be determined.

The object of this article is simply to illustrate the relation between weights of equipment and floor strengths, and certain assumptions have been made which are not strictly accurate but serve the purpose in view.

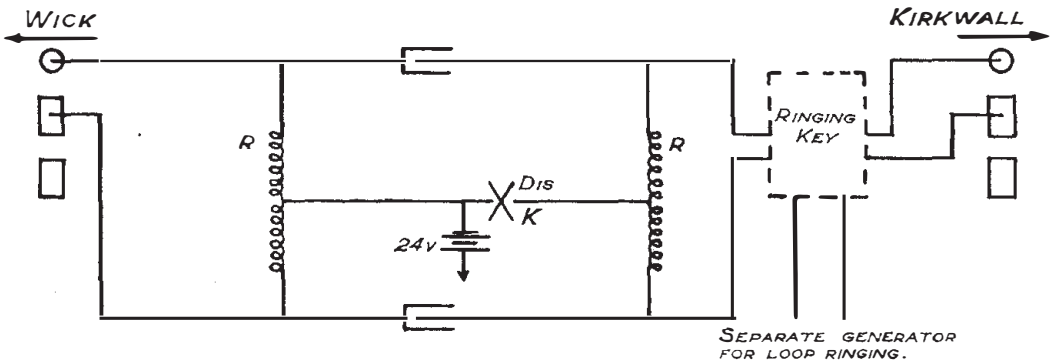
A TELEPHONE REPEATER WITH REMOTE CONTROL.

By A. C. Timmis, B.Sc., A.M.I.E.E., and
H. G. Davis, A.C.G.I., B.Sc., D.I.C.

As a general rule, in this country at least, there are no circumstances which would prevent the control of a repeater at the point of its insertion in a circuit. The peculiar conditions necessitating the operation of a repeater from a distance were found in an attempt to improve speech transmission between the Orkney Islands and the North of Scotland.

Three submarine telegraph cables traverse the Pentland Firth, connecting Kirkwall with Dunnet Head on the Scottish Coast. A first experimental attempt was made to get telephonic communication established over the shortest of these lines, comprising 18.28 nauts of 107/150 cable having a resistance of 183 ohms. The attempt was so far successful as to provide reasonably good speech between Kirkwall and Thurso, and between Kirkwall and Wick. For communication to places beyond Wick, however, the circuit was not considered satisfactory. The Dunnet Head—Thurso and Thurso—Wick circuits were made up of open lines, partly 150 lbs. bronze and partly 150 lbs. copper, together with various short

lengths of 10-lbs. underground cable. In order to improve the uniformity of the circuit and make it more suitable for the introduction of a repeater, several short lengths of underground cable were cut out. It was also found that, with a suitable transfer at Croxter Junction Pole, the Wick—Thurso circuit could be made 150 lbs. copper throughout and similarly the Thurso—Dunnet Head circuit 150 lbs. bronze throughout, thus considerably improving the uniformity. As regards the position of the repeater to be inserted, it was immediately obvious that the best position from the transmission standpoint was at Dunnet Head, where there is only a cable hut. The transmission equivalent of the submarine cable was about 12 S.M., and the equivalents of the open lines



R, R - CLEARING RELAYS.
K - SPECIAL KEY CONTROLLING REPEATER

FIG. 1.—MODIFIED CORD CIRCUIT, THURSO.

4 S.M. and 5 S.M. respectively. No repeater being considered between Dunnet Head—Thurso and Thurso—Wick were about necessary for Thurso—Kirkwall calls, it remained to be arranged for the Dunnet Head repeater to be brought into circuit by the Thurso Exchange operator when Kirkwall was connected to Wick or places beyond. The method of doing this will be understood on reference to the diagrams, of which Fig. 1 shows the modification in the Thurso operator's cord circuit and Fig. 2 the arrangements at the repeater itself. Referring to Fig. 2, which shows the circuit as connected for Thurso—Kirkwall calls with the repeater inoperative, the valve filaments are connected in series with the contacts of a Relay 7A which, when operated, switches on the valves and also operates two Relays 7D, thereby bringing the repeater into circuit. Relay 7A is connected between the mid-point of the line transformer winding and earth, so that the application of − 24v to line will operate the relay and switch the repeater into circuit. This operating voltage is automatically applied to line from the battery in the ordinary C.B.S. cord circuit (Fig. 1)

when the Thurso operator puts Kirkwall through to Wick or places beyond. In the normal case, for Thurso—Kirkwall calls, a special cord circuit is used, having the battery feed disconnected as shown in Fig. 1.

The apparatus installed at the Dunnet Head cable hut consists of two Repeaters No. 3A associated with two Potentiometers 1A and the relays already mentioned. The line and balance transformers on the land line side are of type 16A, while on the submarine cable side two special transformers were wound with a step-down turns ratio from repeater to cable of 2.5 : 1. These transformers were made as nearly alike as possible but without gaps in the cores, such as are used in Transformers No. 16. There is little danger of change in the core of the cable transformer by ringing currents, and earth currents are eliminated by a 4 μf con-

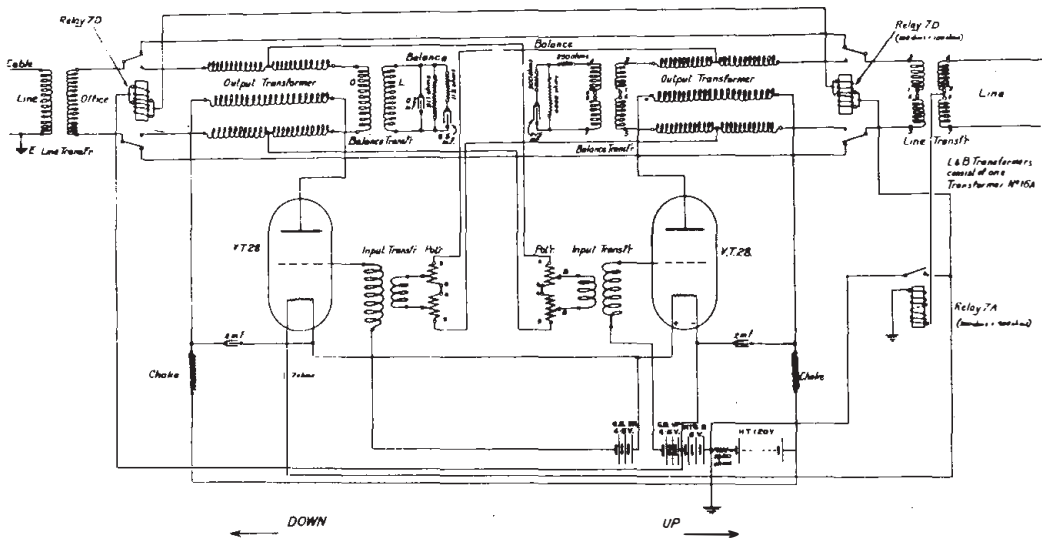


FIG. 2.—TWO-WIRE REPEATER WITH REMOTE CONTROL.

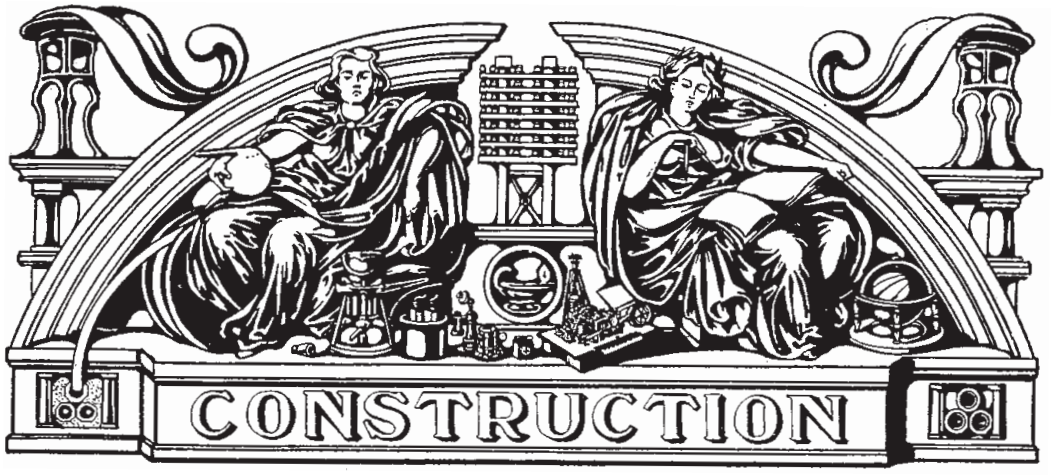
denser in series at the Kirkwall end of the cable. The balances are modifications of the type usually employed for unloaded lines. Under the special conditions of isolation obtaining, it was obviously necessary to depart from the usual practice as regards the valves used, and the repeaters were fitted with dull emitter valves (V.T. 28), operating on a voltage of 2.8 with filament current 60 mA. These valves have an amplification factor of about 6 and an anode impedance of about 20,000 ohms. Dry cells supply the anode voltage. A portable battery of three "Exide" DFG cells was supplied for the filament heating and relay current, these cells giving a satisfactory output under conditions of slow, intermittent discharge, and requiring little or no maintenance attention. This type of battery has given good results so far,

removals for charging being necessary only about once in six weeks. The cable hut is, as might be expected, very damp, and the repeater with its relays, etc., was enclosed in a special box with quicklime as a drying agent, and well sealed with paraffin wax.

The only other modification of the apparatus previously used has been the provision of a special generator at Thurso, fitted for loop ringing only, to be used for ringing Kirkwall. This obviates the operation of the repeater control relay at Dunnet Head when the ordinary earthed generator is used. Subscribers at Kirkwall, a C.B.S. exchange, cannot operate the relay in clearing their calls, nor can Wick subscribers, as their magneto generators are fitted for loop ringing only.

The apparatus as installed has given satisfactory results, improvements of the order of 10 S.M. being regularly obtained. Very good volume from Kirkwall to Aberdeen has been obtained and, by the use of a cord circuit repeater at Inverness, Stromness in the Orkneys can get through to Edinburgh with good results. The introduction of the repeater has opened up new possibilities of communication to the Orkney Islanders, and the improved transmission is already widely known and appreciated.

The repeater was made up in the Research Laboratories, and the necessary line impedance measurements, etc., were made by Mr. R. B. Rae, Scot. E. District, whose co-operation contributed largely to the success of the undertaking.



THE ANGLO-BELGIAN (1926) CONTINUOUSLY-LOADED TELEPHONE CABLE.

By W. T. Palmer, Wh.Ex., B.Sc. (Hons.).

"There is no sound, no echo of sound, in the deserts of the deep;
. . . . . .
Hush! Men talk to-day o'er the waste of the ultimate slime,
And a new Word runs between: whispering 'Let us be one.'"

Just before dawn on the morning of July 30th, 1926, the connection of the largest telephone link between England and the Continent was completed in the grey waters of the North Sea by the cable ship "Faraday." This link—the Anglo-Belgian (1926) continuously-loaded, paper-core, submarine telephone cable—was manufactured at Woolwich by Messrs. Siemens Bros. & Co., Ltd., to whom the task of laying was entrusted.

The total length of cable manufactured consisted of five 10-naut lengths and one spare 5-naut length, which were joined together in the works to form two main portions for the purpose of laying—20 nauts being laid from La Panne (Belgium) and 35 nauts laid from Dumpton Gap (England)—approximately 6½ nauts being cut out and a joint made at sea. A cross-sectional view of the cable with the colour scheme is shown in Fig. 1. There are seven quads (28 conductors) making a total of 21 circuits—2 side circuits and 1 phantom for each quad. The constituent conductors are solid copper of 0.08 inch diameter. Each conductor is wound with a layer of 0.008-inch diameter special iron wire to increase its inductance, and insulated by four layers of paper. The cable core is surrounded by two seamless lead-coverings with a compound filling between. Over these two layers of bitumized paper, served with tarred jute, form a bedding for the armouring of 26 galvanised iron wires each 0.232 inch diameter. Above this lies a double

layer of jute and compound coating. The total diameter of the cable is 2.58 inches and its weight 26½ tons per naut. The length after laying was 48.40 nauts.

Owing to unfavourable conditions when the shore end of the cable was landed at La Panne, the end had to be left 240 yards from the hut. Until an extra length of 240 yards of cable was shipped from England and connected through a sea-joint on the beach to the cable hut, the necessary tests in co-operation with the cable ship were conducted from two bathing machines in which the cable end and apparatus were sheltered. See accompanying photographs. From these improvised testing places cross-talk measurements were taken on all quads, during the making of the joint at sea,

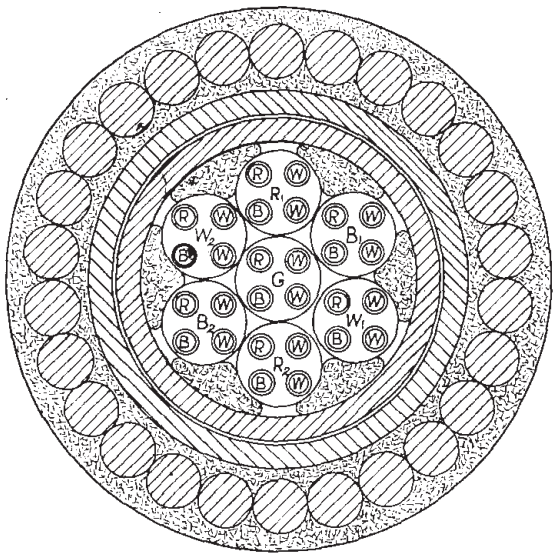


FIG. 1.—CROSS SECTION OF CABLE, FULL SIZE.
R_1 B_1 W_1 DISTINGUISHED BY ORANGE PAPER PACKING PIECES BETWEEN THEM.

by the aid of a switch on the "Faraday," which enabled, if necessary, the wires in a pair or the pairs themselves to be crossed for the purpose of reducing the cross-talk. The results of these tests not only showed that considerable reduction in the readings of the cross-talk meter could be obtained, in some cases, by a selection at this sea-joint, but also emphasised the liability to split pairs owing to the presence of two white cores in the same quad (Fig. 1).

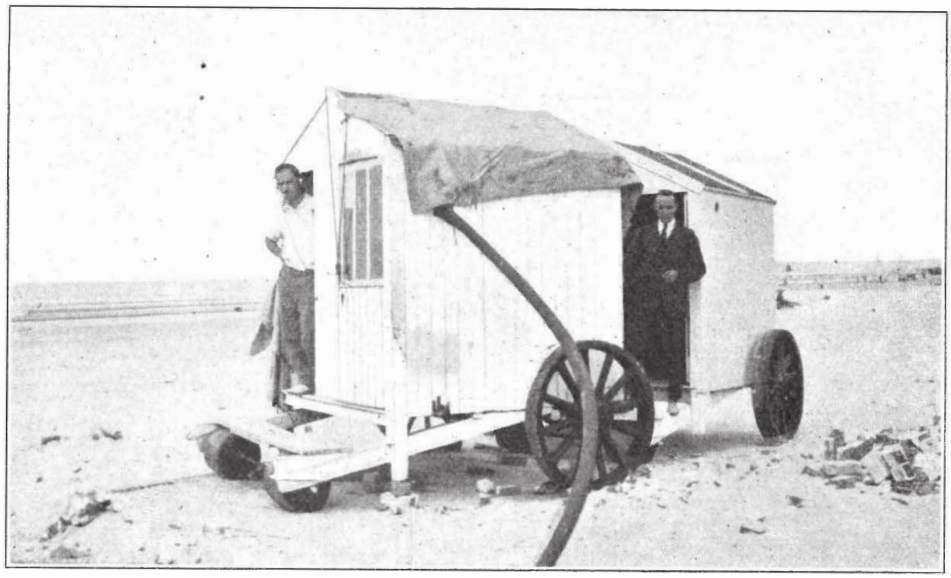
To facilitate the manipulation of the cores during work at sea on cables of this type and to get the best results, even where distinctive colours for each core in the quad may be used, the importance of a rigid programme, agreed upon by all those actually taking part in the tests, cannot be too greatly emphasised, and once drawn up *only unavoidable circumstances should interfere with this programme*.

From tests made on the cable after it was joined through to the hut at La Panne, the following results are taken :—

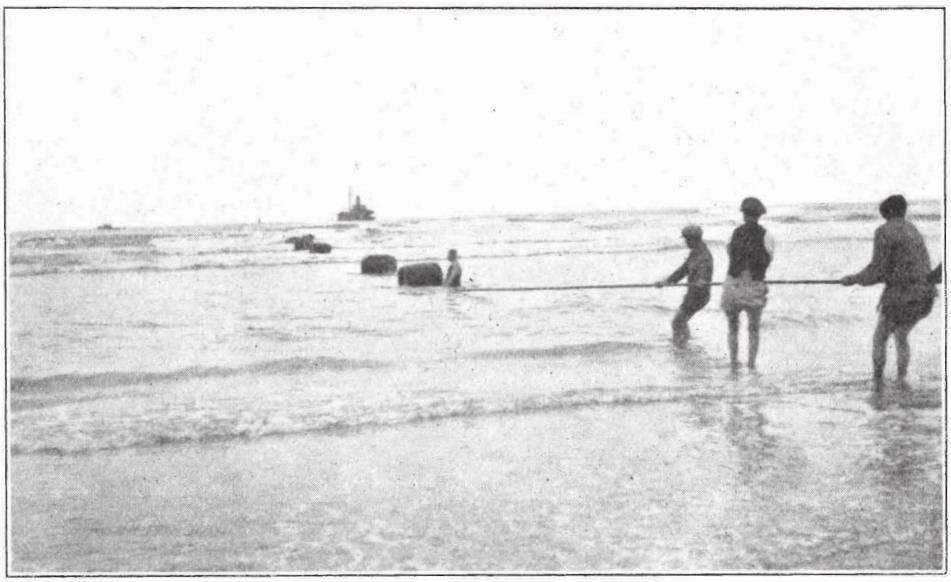
Direct Current Tests.

a. Mean conductor resistance of the 28 cores = 9.89 ohms per naut.

b. Mean insulation resistance, measured with 170 volts, between each core and all the other cores earthed and after 1 min. electrification = 32,●●● megohms per naut.



Bathing Machines used as Test Hut. Dr. Rosen in shirt sleeves.



Floating in Shore End at La Panne.

FINAL PULL AT LA PANNE. LADIES NOT INTERESTED.

ALTERNATING CURRENT TESTS.

a. Transmission Efficiency and Distortion. Each circuit was measured for its attenuation constant and characteristic impedance from both ends with a testing current of 1 *m.a.* at a frequency corresponding to an angular velocity of 5,000 radians per second. The mean results are shown in Table I.

TABLE I.

ATTENUATION CONSTANT AND CHARACTERISTIC IMPEDANCE AT $\omega = 5000$ RADS./SEC. FOR LENGTH OF CABLE = 48.40 NAUTS. MEAN OF TESTS FROM EACH END.

Circuit.	Attenuation Constant per Naut. Loop $\equiv \beta$		Characteristic Impedance in Vector Ohms $\equiv Z_0 \lfloor \overline{\phi_0}$	
	From La Panne.	From Dumpton Gap.	From La Panne.	From Dumpton Gap.
Average of the 12 pairs in the outer quads	.0275	.0276	395 $\lfloor \overline{9°2'}$	388 $\lfloor \overline{9°0'}$
Average of the 6 outer phantom circuits	.0331	.0332	161.5 $\lfloor \overline{9°47'}$	158 $\lfloor \overline{9°18'}$
Average of the 2 pairs of the centre quad	.0273$_5$	.0274	391.5 $\lfloor \overline{9°0'}$	388 $\lfloor \overline{8°15'}$
Phantom circuit of centre quad	.0332	.0332	160 $\lfloor \overline{9°48'}$	158 $\lfloor \overline{8°32'}$

From Table I. the side circuits of the cable are found to be approximately equivalent to 12.5 M.S.C. and the phantom circuits to 15.1 M.S.C.

The variation of the attenuation constant with frequency for a selected pair and phantom is shown in Fig. 2. From the curves in this figure it can be shown that the mean distortion for the side and phantom circuits between $\omega = 2{,}000$ and $\omega = 12{,}500$ rads. per sec. is equivalent to a βl of approximately 0.322 or an equivalent distortion of nearly 3 M.S.C. in either case.

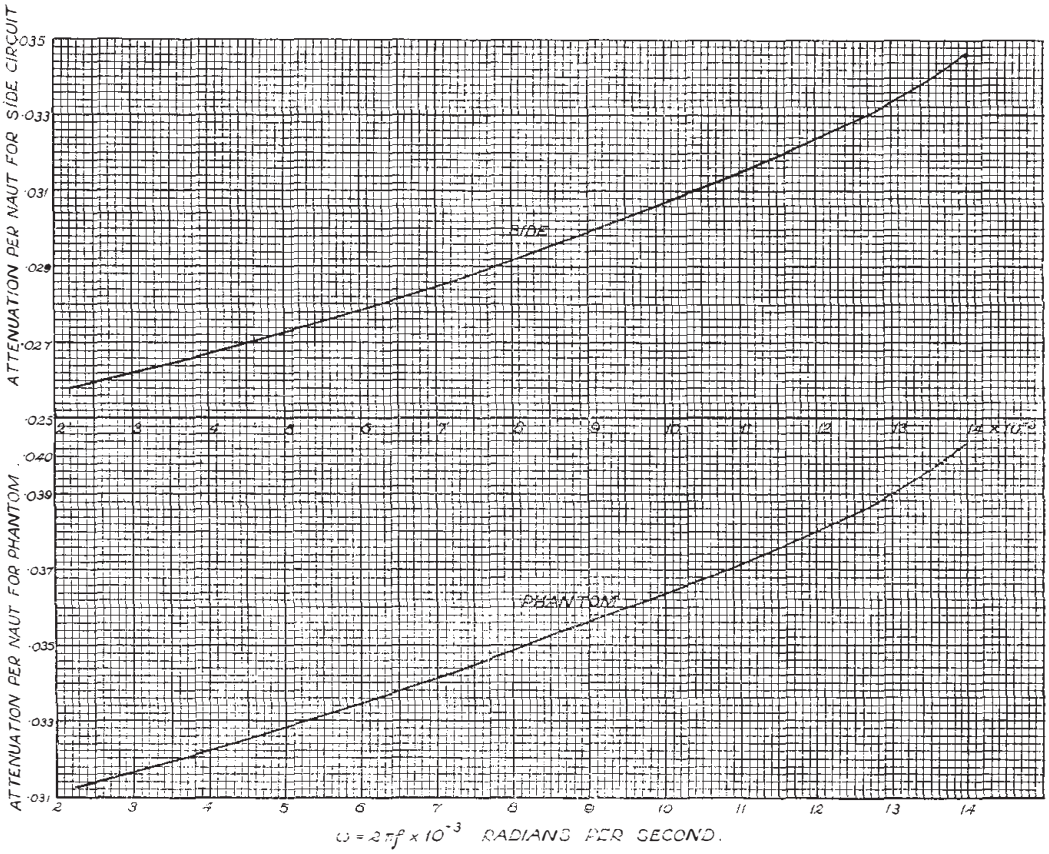


FIG. 2.—MEAN ATTENUATION-FREQUENCY CHARACTERISTICS FOR SIDE AND PHANTOM CIRCUITS OF THE ANGLO-BELGIAN (1926) SUBMARINE TELEPHONE CABLE.

The arrangement of the apparatus used to obtain the curves in Fig. 2 is given in Fig. 3 (see article by H. F. Mayer in "Elektrische Nachrichten-Technik," Vol. 3, No. 4, for April, 1926). This is a much simpler and quicker method than the "open and closed impedance" method, and check tests made by the latter agreed exactly with the results of the former. In Fig. 3 silence was obtained in the telephone by adjusting the frequency f and the resistance r. Then the following relation holds if the line is electrically long:—

$$e^{\beta l} = \frac{V_1}{V_2} = \frac{r + 2R}{r/2}$$

where V_1 = voltage at sending end of cable.
V_2 = voltage at receiving end of cable.
β = attenuation constant per naut loop.
l = total length of circuit in nauts.

Hence $\beta = \frac{1}{l} \log_e \frac{2(r + 2R)}{r}$

By reversing the connections on one pair intermediate values of ω can be obtained and assuming

$$\alpha \fallingdotseq 2\pi f \sqrt{CL} \fallingdotseq \omega \sqrt{CL}$$

where α = wave-length constant per naut loop.
C = capacity of cable, in farads, per naut loop.
L = inductance of cable, in henries, per naut loop.

We have the intervals ω_1 between the values of ω, for which silence is obtained in the telephone, given by

$$\omega_1 \fallingdotseq \frac{\pi}{\sqrt{CL}} \times \frac{1}{\text{length of circuit in nauts.}}$$

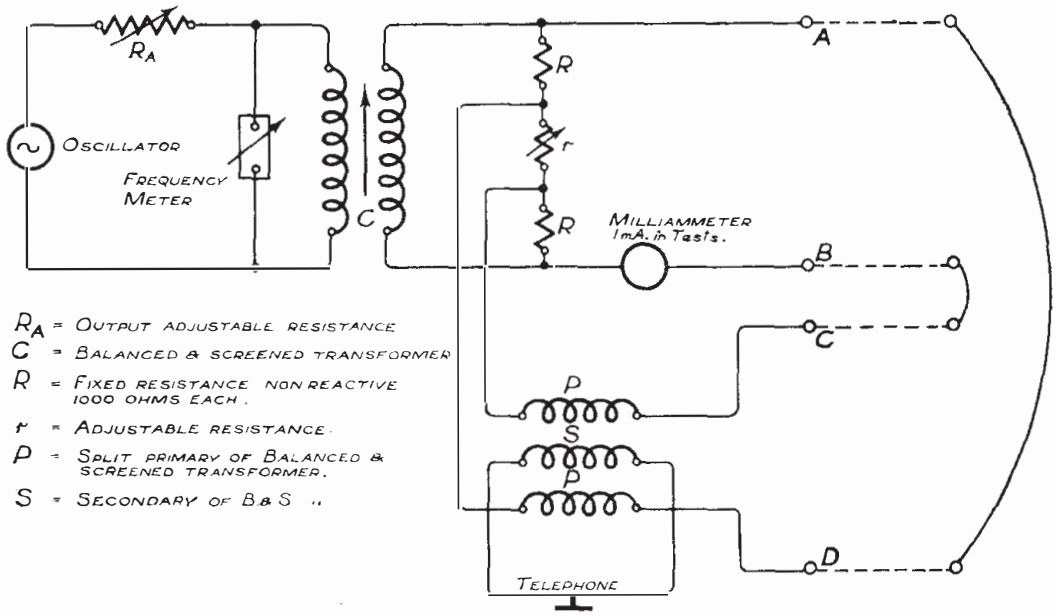


FIG. 3.

The advantages of this method are:—

(1) It can be used on lines too long for the application of the open and closed impedance method.

(2) The value of β is easily calculated and the required curve drawn whilst the test is in progress.

(3) The value of the frequency does not enter into the calculation for β and need not be known with extreme accuracy.

b. Uniformity of Electrical Constants. The uniformity of electrical constants—resistance, inductance, capacity and leakance—can be investigated by plotting the impedance-frequency curve of each circuit and noting how far this curve deviates from a smooth mean curve drawn through it. A sudden change in the

value of one or more of the constants will result in reflection of the current and voltage waves at the change of impedance and, if the change be big enough, will cause the impedance-frequency curve to be undulated.

In the case of tests made on this type of cable the mean impedance-frequency curve of each circuit has, generally speaking, a "falling" characteristic, *i.e.*, one in which the impedance decreases with frequency. The explanation of this is considered in an Appendix, where it is shown that the characteristic imped-

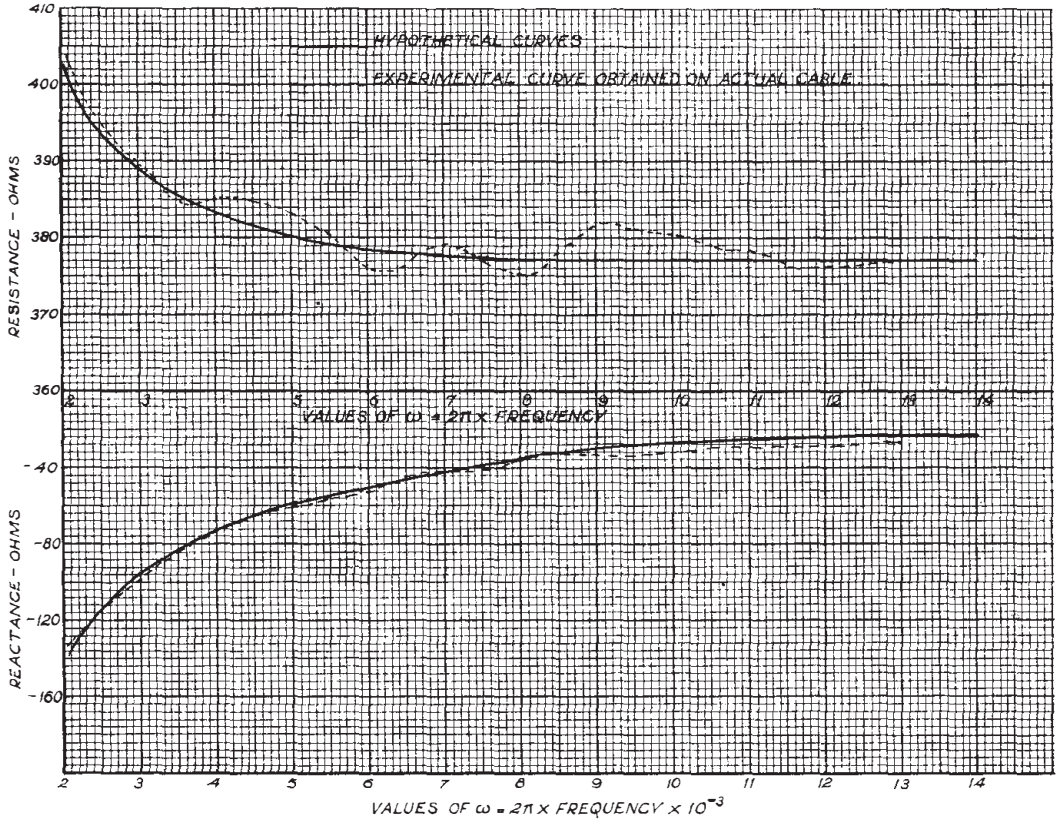


FIG. 4.—HYPOTHETICAL IMPEDANCE-FREQUENCY CHARACTERISTICS FOR SIDE CIRCUITS OF ANGLO-BELGIAN (1926) CABLE.

ance Z_0 of a hypothetical loaded cable having uniform constants throughout its length has a magnitude given by the formula:

$$Z_0^4 = \frac{M}{\omega^2} + N \qquad \ldots\ldots\ldots\

From equations (1) and (2) the resistance and reactance components have been caluculated for a hypothetical cable having the average constants of the side circuits of the Anglo-Belgian (1926) Cable, and are shown in Fig. **4**, together with similar curves obtained by measurement on the actual cable. It will be seen that the hypothetical curves form good means of the actual curves.

From tests made upon the separate 10-naut manufactured lengths it was known that the 20 nauts on the Belgian side of the sea-joint have a slightly higher average capacity than the length of cable on the English side of the joint. This discontinuity of

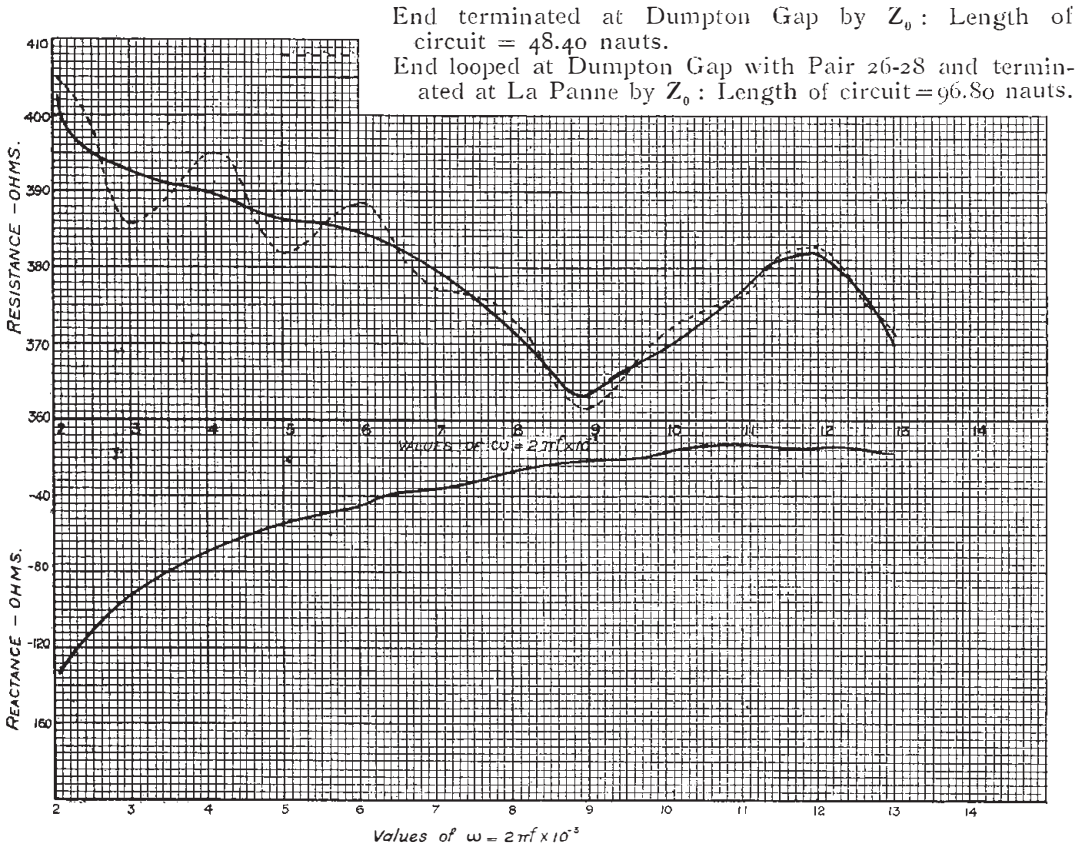

End terminated at Dumpton Gap by Z_0 : Length of circuit = 48.40 nauts.
End looped at Dumpton Gap with Pair 26-28 and terminated at La Panne by Z_0 : Length of circuit = 96.80 nauts.
RESISTANCE - OHMS.
REACTANCE - OHMS.
Values of $\omega = 2\pi f \times 10^{-3}$

FIG. 5.—IMPEDANCE-FREQUENCY CHARACTERISTICS OF PAIR 25-27 TAKEN FROM LA PANNE WITH TESTING CURRENT OF 1 M.A.

uniformity has affected the impedance-frequency characteristics of the circuits by producing an undulation which in some cases is ill-defined, but in others, especially from La Panne, is quite distinct. All the circuits were tested for impedance over a range of ω from 2,000 rads. per sec. to 13,000 rads. per sec., and as typical examples, Figs. **5**, **6**, **7** and **8** are given. Fig. **5** refers to the centre quad and the dotted curve shows the result of testing with pair 25-27 terminated at Dumpton Gap by a resistance adjusted to be equal to the real part of the characteristic impedance, and giving a circuit only 48.40 nauts in length—approximately

12.5 M.S.C. It will be seen that this dotted curve has " bumps " with a period of roughly $\omega = 2{,}000$ radians per second, which indicates reflection at about 48 nauts from La Panne,* *i.e.*, at Dumpton Gap, and is due to the absence from the termination of the reactive portion of the characteristic impedance—the ratio of the reactance to the resistance portion being of the order of 20% at the lower frequencies where the amplitudes of the " bumps " are greatest. The full curve was obtained by looping pair 25-27

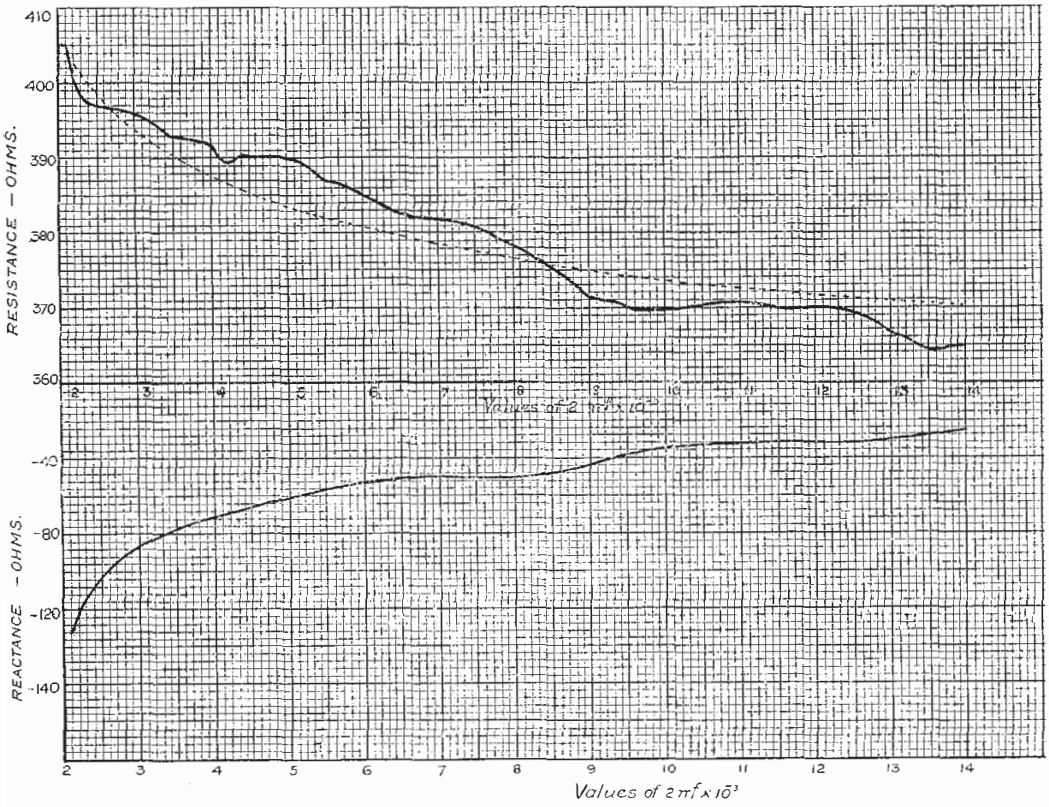


FIG. 6.—IMPEDANCE-FREQUENCY CHARACTERISTICS TAKEN FROM LA PANNE ON PAIR 1-3 WITH A TESTING CURRENT OF 1 M.A.

to pair 26-28 at Dumpton Gap to give a circuit 96.80 nauts in length (approximately 25 M.S.C. and approaching the infinite line condition), whilst pair 26-28 was closed at La Panne through a resistance which was varied with the frequency to be equal to the real part of the characteristic impedance. It is interesting to note that the bigger undulation has roughly a period of $\omega = 5{,}000$ rads. per sec., which indicates reflection at a distance nearly 19 nauts from La Panne, *i.e.*, near the sea-joint, and it is in that region where the change of average cable capacity, already referred to, takes place.

Figs. **6** and **7** refer to tests on pair 1-3 looped to pair 2-4

* See Paper No. 76 of the I.P.O.E.E., by Robinson and Chamney, p. 112.

(circuits in an outer quad) taken from La Panne and Dumpton Gap.

Fig. **8** gives the resistance-components of the phantom circuits for the centre and one outer quad.

These curves are drawn to a large scale and in Figs. **6** and **7** the maximum deviation of each from a mean curve is less than ± 2%, whilst in no case did the variation exceed ± 5%, the figure guaranteed by the Makers.

c. Interference between Circuits. Cross-talk measurements were made on an equivalent current basis (1) with the P.O.

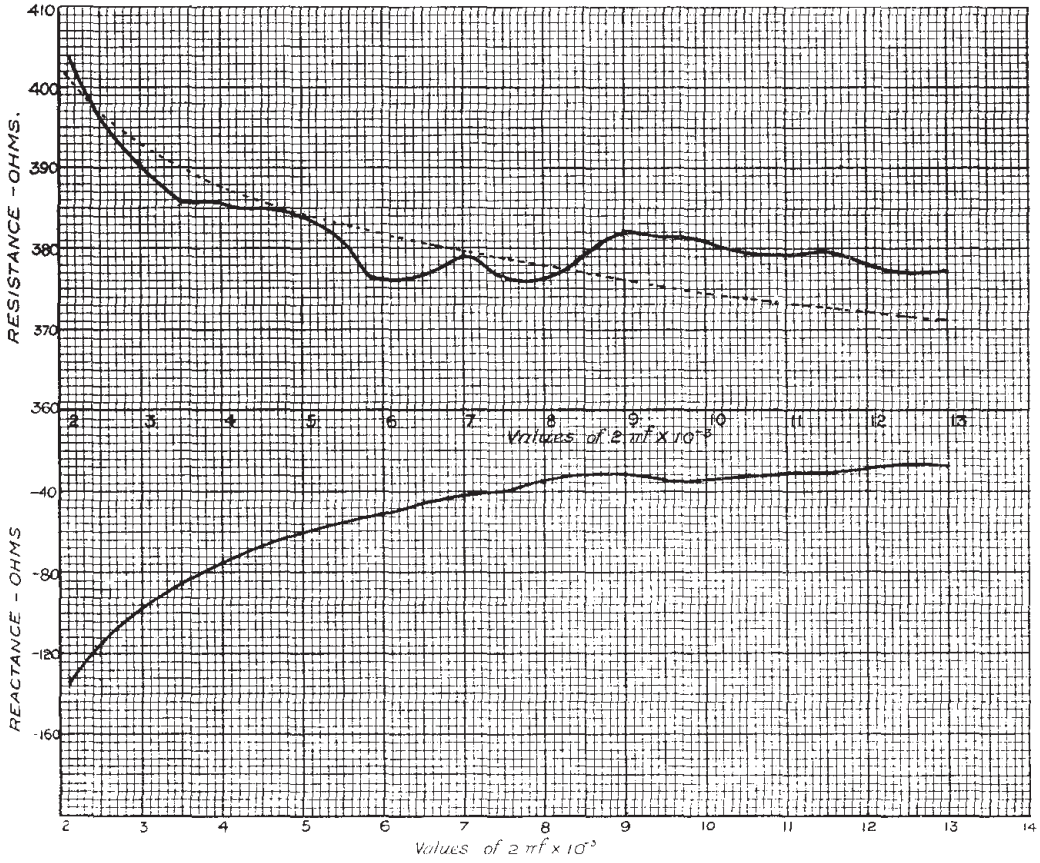


FIG. **7**.—IMSEDANCE-FREQUENCY CHARACTERISTICS TAKEN FROM DUMPTON GAP ON PAIR 1-3 WITH A TESTING CURRENT OF 1 M.A.

apparatus using a Western Electric Cross-Talk Meter, which expresses the induced current in millionths of the inducing current, and (2) with the Siemens and Halske apparatus, which expresses the interference between circuits in βl-units. In both of these methods, if the true value of the interference be required, it is necessary to make allowance for the effect of the end apparatus and for the difference in impedance between the disturbed and the disturbing circuits.

One of the chief objections to measuring interference with

speech or reed hummer (largely counterbalanced by the celerity and simplicity of the method) is due to the fact that very often the observer has to judge equality between two sounds of different timbre. This difference may be so great that even experienced observers will record different results. To give examples of the difference the results of two such observers, X and Y, are given in Tables III. and IV.

(1) *Tests with P.O. Apparatus.* The cross-talk between circuits within each of the seven quads was measured, using speech as the source of disturbance—See Table II.—and also with a reed hummer for the disturbing source—See Table III.

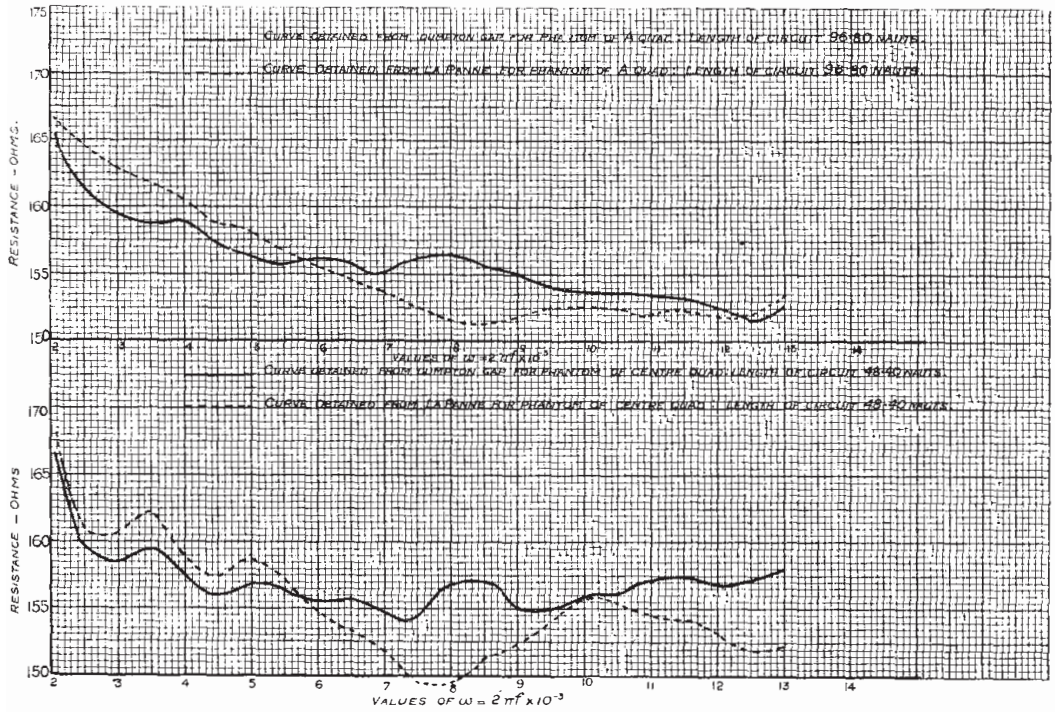


FIG. 8.—RESISTANCE COMPONENTS OF IMPEDANCE-FREQUENCY CURVES FOR PHANTOM CIRCUITS OF "A" QUAD AND G (CENTRE) QUAD, TAKEN FROM BOTH ENDS OF THE CABLE.

The results in Table II. are simply the meter readings, but in Table III. the actual readings have been corrected to allow for the effect of external apparatus and for difference in impedance between the disturbed and disturbing circuits* and then converted to βl-units.

The maximum cross-talk reading obtained between circuits in different quads with speech did not exceed 130 and in most cases the reading was less than 20.

* See Paper by A. Rosen, *Journal I.E.E.*, p. 849, Vol. 64, August, 1926.

(2) *Tests with Siemens and Halske Apparatus.* Cross-talk results obtained with this apparatus are measured directly in βl-units.

A reed hummer was used as the source of disturbance and Table IV. gives the results obtained for side to side and phantom to side cross-talk in each of the seven quads, corrected to allow for end apparatus and for different circuit impedances.

The corrected figures in Tables III. and IV. agree fairly well, and most of the existing differences are probably due to the difficulty mentioned above.

TABLE II.

CROSS-TALK WITHIN QUADS MEASURED WITH P.O. APPARATUS.

Meter readings taken with the distant end of the cable closed through repeating coils by its characteristic impedance. Meter in parallel.

RW_1 ≡ Red—White pair of the quad.
BW_2 ≡ Blue—White ,, ,, ,, ,,
\+ ≡ Phantom circuit ,, ,, ,,

SOURCE OF DISTURBANCE—SPEECH.

Tests from La Panne (Hut).					*Tests from Dumpton Gap (Hut).**				
Speaking on :—		Listening on :—			Speaking on :—		Listening on :—		
Quad.	Cct.	RW_1	BW_2	+	Quad.	Cct.	RW_1	BW_2	+
G (Centre)	RW_1	—	100	700	G (Centre)	RW_1	—	200	550
	BW_2	100	—	600		BW_2	190	—	370
	+	800	900	—		+	800	430	—
A	RW_1	—	140	1000	A	RW_1	—	130	1200
	BW_2	140	—	800		BW_2	130	—	350
	+	1400	1000	—		+	1400	550	—
B	RW_1	—	170	1000	B	RW_1	—	300	600
	BW_2	170	—	600		BW_2	280	—	600
	+	1500	700	—		+	800	700	—
C	RW_1	—	100	700	C	RW_1	—	230	700
	BW_2	100	—	1000		BW_2	260	—	450
	+	1000	1400	—		+	900	600	—
D	RW_1	—	130	800	D	RW_1	—	140	480
	BW_2	130	—	800		BW_2	140	—	800
	+	1000	2000	—		+	700	1200	—
E	RW_1	—	130	500	E	RW_1	—	90	1100
	BW_2	130	—	600		BW_2	80	—	450
	+	700	800	—		+	1600	750	—
F	RW_1	—	130	800	F	RW_1	—	280	500
	BW_2	130	—	800		BW_2	280	—	400
	+	1000	1000	—		+	700	450	—

* During the laying operations, 500 yards were cut from the English end and this is probably the cause of the fact that the average side to side cross-talk figures from Dumpton Gap are higher than those taken either in the Works or at La Panne.

TABLE III.

CROSS-TALK WITHIN QUADS MEASURED WITH P.O. APPARATUS.
SOURCE OF DISTURBANCE—REED HUMMER.

Testing Conditions as in Table II.

Quad.	Red—White to Blue—White.				Phantom to Red—White Pair.				Phantom to Blue—White Pair.			
	Meter Reading.		Corrected βl-units.		Meter Reading.		Corrected βl-units.		Meter Reading.		Corrected βl-units.	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
G	70	50	9.9	10.1	1200	1300	7.5	7.5	1400	1500	7.4	7.3
A	200	250	8.8	8.5	900	1200	7.8	7.5	1700	2000	7.2	7.0
B	150	200	9.0	8.5	1600	2000	7.2	7.0	1200	1200	7.5	7.5
C	100	100	9.4	9.4	1000	1400	7.7	7.4	1200	1600	7.5	7.2
D	120	100	9.3	9.4	800	800	7.9	7.9	2500	3000	6.8	6.6
E	130	130	9.2	9.2	1400	1400	7.7	7.7	1200	1100	7.5	7.6
F	130	160	9.2	9.0	2000	2500	7.0	6.8	2500	2500	6.8	6.8

TABLE IV.

CROSS-TALK WITHIN QUADS MEASURED WITH SIEMENS & HALSKE APPARATUS.

SOURCE OF DISTURBANCE—REED HUMMER.

Resistances Used at Sending End instead of Repeating Coils: P.O. Distant End Sets used.

Quad.	Red—White to Blue—White.				Phantom to Red—White Pair.				Phantom to Blue—White Pair.			
	Meter Reading.		Corrected βl-units.		Meter Reading.		Corrected βl-units.		Meter Reading.		Corrected βl-units.	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
G	10.0	9.5	9.7	9.2	9.3	9.2	7.6	7.5	9.2	9.2	7.5	7.5
A	8.7	8.8	8.4	8.5	9.4	9.4	7.7	7.7	9.0	9.1	7.3	7.4
B	9.0	8.9	8.7	8.6	8.9	8.9	7.2	7.2	9.3	9.2	7.6	7.5
C	9.7	9.7	9.4	9.4	9.4	9.4	7.7	7.7	9.1	9.3	7.4	7.6
D	9.5	9.6	9.2	9.3	9.6	9.5	7.9	7.8	8.6	8.7	6.9	7.0
E	9.3	9.4	9.0	9.1	9.1	9.3	7.4	7.6	9.5	9.5	7.8	7.8
F	9.1	9.0	8.8	8.7	8.8	8.8	7.1	7.1	8.8	8.9	7.1	7.2

d. Magnetic Stability. A direct current of 100 milliamperes sent through one core in a quad produced an approximate increase of inductance of only 0.2%.

A repeater station is being constructed at La Panne in which this Anglo-Belgian cable will be terminated and from which will radiate continental land circuits, further repeatered, each many hundreds of miles in length. From Dumpton Gap the cable will be joined through to a repeater station at Canterbury by means of 18½ miles of land cable of similar construction to the sea length (except for the armouring) and having the same electrical

characteristics. This land cable has been separately tested and found to be satisfactory, and further tests on the completed cable from Canterbury to La Panne will be made as soon as the jointing operations are completed at Dumpton Gap.

APPENDIX.

RELATION BETWEEN THE CHARACTERISTIC IMPEDANCE OF A CONTINUOUSLY-LOADED CABLE AND THE FREQUENCY OF TESTING CURRENT.

In the case of a hypothetical cable having perfectly uniform electrical constants throughout its length, the characteristic impedance, expressed in vector ohms, is given by the expression—

$$Z_0 \angle\phi_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

where $\omega = 2\pi \times$ frequency of testing current.
R = resistance per unit length of circuit in ohms.
L = inductance ,, ,, ,, ,, ,, henries.
G = leakance ,, ,, ,, ,, ,, mhos.
C = capacity ,, ,, ,, ,, ,, farads.
Z_0 = the magnitude of the vector and is given numerically by

$$Z_0 = \sqrt[4]{\frac{R^2 + \omega^2 L^2}{G^2 + \omega^2 C^2}} \qquad \ldots\ldots(1)$$

ϕ_0 = the angle of the vector and is found in magnitude and sign from

$$\text{Tan } 2\phi_0 = \frac{\frac{\omega L}{R} - \frac{\omega C}{G}}{1 + \frac{\omega^2 LC}{GR}} \qquad \ldots\ldots(2)$$

We can obtain Z_0 and ϕ_0 in terms of ω from equations (1) and (2) with sufficient accuracy by substituting for R, L, G and C the following expressions obtained by observation on continuously-loaded cables already manufactured :—

$$R = a\omega^2 + b$$

and $G = d\omega$ for values of ω throughout the audio-range and where a, b and d are constants for the particular cable under consideration.

L and C may be considered as constant within the audio-range of frequencies. Hence :—

$$Z_0 = \sqrt[4]{\frac{(a\omega^2 + b)^2 + \omega^2 L^2}{d^2\omega^2 + C^2\omega^2}}$$

and $\therefore Z_0^4 = \frac{M}{\omega^2} + N + Q\omega^2 \qquad \ldots\ldots(3)$

where M, N and Q are constants; $M = \frac{b^2}{C^2 + d^2}$, $N = \frac{2ab + L^2}{C^2 + d^2}$ and $Q = \frac{a^2}{C^2 + d^2}$.

By differentiation of the right hand side of (3) with respect to ω it will be seen that the slope of the impedance-frequency curve will be negative for values of ω up to $\omega = \sqrt{\frac{M}{Q}}$. In practice, the value given by $\omega = \sqrt{M/Q}$ is always far beyond the upper limit of important speech frequencies and further, the value of $Q\omega^2$ in comparison with M/ω^2 may be neglected. *Hence we may say that in a continuously-loaded cable the value of the characteristic impedance decreases with increase of frequency very nearly according to the law—*

$$Z_0^4 = \frac{M}{\omega^2} + N \qquad \ldots\ldots(4)$$

Equation (2) can be written

$$\text{Tan } 2\phi_0 = \frac{\frac{\omega L d}{a\omega^2 + b} - C}{d + \frac{\omega LC}{a\omega^2 + b}} \qquad \ldots\ldots(5)$$

Differentiating with respect to ω

$$\therefore \frac{d(\text{Tan } 2\phi_0)}{d\omega} = \frac{L(C^2 + d^2)(b - a\omega^2)}{(\text{denominator})^2}$$

This last expression is +ve if $b > a\omega^2$. In practice b is always much greater than $a\omega^2$ within the audio-range of ω, and therefore *the characteristic angle ϕ_0 (as given by equation 5) increases in a +ve direction as ω increases.*

As a further close approximation for the angle ϕ_0 the terms containing d and a in equation (5) may be neglected, giving

$$\text{Tan } 2\phi_0 \fallingdotseq -\frac{b}{\omega L} \qquad \ldots\ldots(6)$$

From (6) for small values of ϕ_0 we have

$$\phi_0 \propto \frac{1}{\omega} \text{ approximately.}$$

Example :—Using equations (4) and (6) the hypothetical resistance and reactance components ($Z_0 \cos \phi_0$ and $Z_0 \sin \phi_0$ respectively) for the chracteristic impedance of the side circuits of the Anglo-Belgian (1926) Submarine Telephone Cable have been calculated

and are given in the Table below. They are shown plotted in Fig. **4** together with similar curves obtained by measurement on the actual cable. The values of the constants for this cable are as follows :—

$$a = 0.025 \times 10^{-6}$$
$$b = 20.2$$
$$C = 0.089 \times 10^{-6}$$
$$d = 4.0 \times 10^{-10}$$
$$L = 12.7 \times 10^{-3}$$

From which we have

$$M = 5.151 \times 10^{16}$$
$$N = 2.002 \times 10^{10}$$
$$Q = 0.05051$$

TABLE SHOWING HYPOTHETICAL IMPEDANCE COMPONENTS FOR ANGLO-BELGIAN (1926) SIDE-CIRCUITS.

ω	2000	3000	4000	5000	6000	8000	10000	12000	14000
Z_0	426	401	391	386	383	380	378	378	377
ϕ_0	$-19^\circ\ 15'$	$-13^\circ\ 58'$	$-10^\circ\ 52'$	$-8^\circ\ 50'$	$-7^\circ\ 26'$	$-5^\circ\ 37'$	$-4^\circ\ 31'$	$-3^\circ\ 47'$	$-3^\circ\ 15'$
R_0	402	389	384	381	379	378	377	377	377
X_0	−140	−96	−73	−59	−49	−37	−30	−25	−22

CORROSION OF LEAD-COVERED CABLES BY ELECTROLYTIC AND CHEMICAL ACTION.

A SUB-COMMITTEE or the Comité Consultatif International des Communications Téléphoniques à Grande Distance (the C.C.I.) met at Berne, Switzerland, on the 13th September, 1926, to prepare reports on the above subjects for presentation to the plenary meeting of the full Committee held in Paris on 29th November, 1926. The Sub-Committee consisted of Engineers from the Telephone Administrations of France (3), Germany (2), Switzerland (3), and Great Britain (1), the Chairman being Dr. Bresig, Germany. The Committee also had the assistance of M. Bourquin, an engineer attached to the Swiss Permanent Commission on Corrosion, a body concerned solely with the prevention and mitigation of the effects of electrolytic action by stray current from electrical systems. This Commission is composed of representatives from

the Swiss Society of Gas and Water Industries, the Swiss Union of Secondary Railways, the Swiss Association of Electricians, and the Swiss Direction General of Telegraphs. Agreed regulations of a comprehensive character have been drawn up by the Commission and special investigations are carried out as required by its engineers.

The Sub-Committee was very fully engaged for 6 days thrashing out the subjects and preparing the reports, but had a little relaxation one afternoon when, as the guests of the Swiss Telegraph Administration, they were taken for a motor trip to Beatenberg, above Lake Thun. The group photograph on this page was

Left to right:—M. Trechsel (Switzerland), M. Bourquin (Switzerland), Dr. Jaeger (Germany), M. Valensi (Secretaire-General C.C.I.), M. Muri (Switzerland), M. Bartholomew (Great Britain), M. Milon (France), Dr. Breisig (Germany), M. Collet (France), Dr. Forrer (Switzerland).

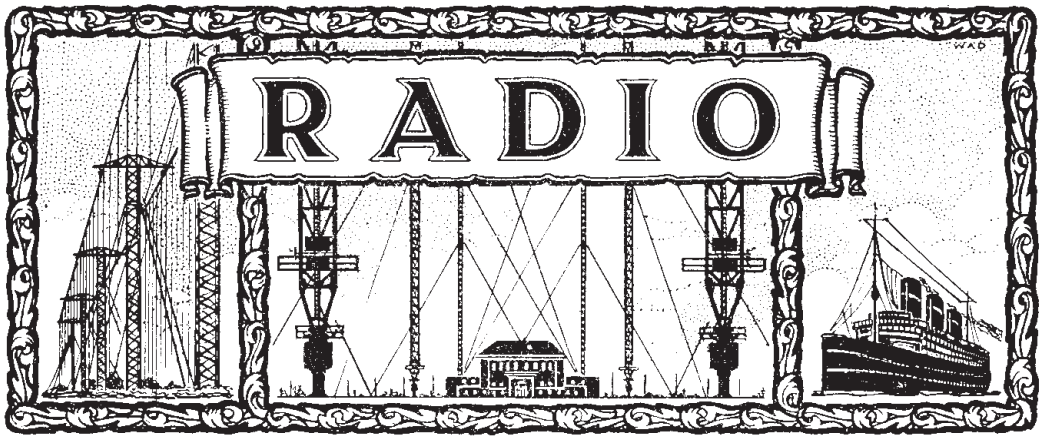
taken at Beatenberg and shows the members of the Sub-Committee with the Eiger, Monch and Jungfrau in the background. The trip was most enjoyable, the weather being perfect and the arrangements made by the Swiss hosts for the comfort of their guests were most excellent.

Mr. S. C. Bartholomew, the representative of the British Post Office, unfortunately met with an accident on the day he was returning to London, when, owing to the sudden stopping of a train, he was thrown along the corridor and broke several ribs.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 20TH SEPTEMBER, 1926.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
504,809	568	4,181	53,901	444	London	23,780	58,430	1,747,012	69,061
61,502	1,881	21,450	60,247	1,785	S. East	3,827	39,424	130,703	16,271
66,211	4,496	27,752	48,572	2,183	S. West	15,114	7,298	111,704	55,937
48,487	8,391	32,764	45,233	3,254	Eastern	13,872	29,043	74,839	65,676
84,688	8,635	42,097	53,793	3,868	N. Mid.	22,658	41,544	176,299	124,076
63,566	4,872	28,346	61,843	3,771	S. Mid.	12,554	18,264	124,748	84,845
54,184	4,851	29,085	47,451	2,158	S. Wales	5,522	21,198	94,596	69,615
88,294	8,277	24,885	45,812	4,983	N. Wales	12,596	36,876	191,905	55,971
139,359	1,585	17,165	42,481	2,821	S. Lancs.	12,662	74,448	407,613	43,366
82,148	6,053	30,865	43,302	2,963	N. East	10,158	37,985	188,190	43,329
56,047	3,645	24,178	35,443	1,745	N. West	8,586	31,376	130,584	37,180
42,013	2,312	15,728	23,386	2,480	North	4,493	10,106	81 848	55,348
19,292	4,811	6,427	12,573	278	Ireland N.	142	251	35,562	712
58,182	5,356	23,525	34,672	1,269	Scot. East	2,673	8,971	114,806	50,944
78,346	7,436	23,806	40,834	812	Scot. West	12,258	22,543	200,253	33,407
1,447,128	73,169	352,254	649,543	34,814	Totals.	160,895	437,757	3,810,671	805,738
1,424,786	73,131	349,769	645,430	36,056	Figures on 30th June, 1926.	157,729	419,852	3,654,998	725,002



THE RUGBY RADIO STATION.

By E. H. Shaughnessy, O.B.E., M.I.E.E.

The Rugby Radio Station of the British Post Office is situated at Hillmorton, about 4 miles south east of Rugby, and occupies a site about 1½ miles long by 1 mile wide. The station buildings are erected at about the middle of the site (see Figs. **1** and **2**).

Power Supply.

The relative advantages of either installing prime movers or purchasing a bulk supply of power were investigated, with the result that it was decided to obtain a bulk supply from the Leicestershire and Warwickshire Electric Power Co. The incoming supply is three-phase, 50 cycle, alternating current, having an earthed neutral and 12,000 volts between phases. Duplicate Underground Mains are provided between the Company's sub-station at Rugby and the Radio Station. The decision to use water-cooled three-electrode valves rendered it necessary to change the incoming alternating current supply into a high tension direct current supply of the order of 10,000 volts and, after considering the merits of mercury-arc rectifiers, thermionic valve rectifiers and motor generators for this purpose, it was decided to instal the latter. The main machinery hall, Fig. **3**, is 185 feet long by 47 feet wide, spanned by an 11-ton overhead travelling crane. The height of the room is 32 feet. Parallel with this main hall is an annex, the lower portion of which contains a battery room and six transformer rooms; the upper floor is a switch gallery open to the main machinery hall. This gallery contains the high and low tension A.C. switchboards, high tension A.C. starting cubicles

for the main motor generators, and the low tension D.C. switchboard.

In the machinery hall are three main motor-generator sets for providing high tension direct current to the valves, two frequency converter motor-generators for heating valve filaments, together with motor starting cubicles and alternator control panels, and also two motor-generator and booster sets for battery charging and low tension D.C. supply. All power, other than that required for the main motor-generators, is supplied by two auxiliary step-down transformers (12000/416 volt) of 450 KVA output through the main low tension A.C. switchboard.

The extra high tension A.C. switchboard is a 6-panel board, consisting of 5 truck cubicles and a Company's metering cubicle.

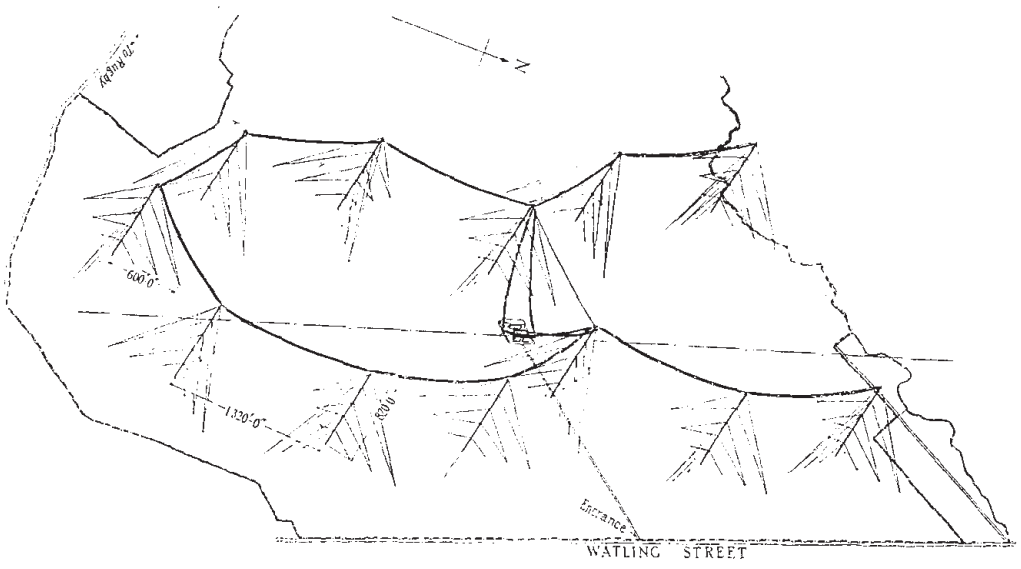


FIG. 1.—ISOMETRIC VIEW OF STATION.

One panel is used for the Department's metering; two panels are connected to the auxiliary 450 KVA transformers situated immediately below the switchboard; the fourth panel of 2,000 k.w. capacity controls the supply to the main motor-generator starting cubicles and one is spare and interchangeable with the others. The low tension A.C. 416 volt switchboard is of the normal slate pattern, containing 16 panels. The requirements of the high frequency valve generator equipment called for the supply of direct current power of from 1,000 k.w. to 1,500 k.w. at a potential of from 8000 to 18000 volts with the negative side at earth potential. Owing to possible failure of valves, the source of supply has to be capable of standing a dead short-circuit with impunity and operate under rapidly fluctuating loads, low self inductance and absence of voltage ripple.

To meet this requirement the high tension D.C. supply to the valves is provided by means of motor-generator sets operating in series as required. The sets, Fig. 4, were made by the British Thomson-Houston Company at their Rugby Works. Each set consists of one synchronous motor, 640 KVA, wound for 2200 volts between phases, driving two 3000 volt single commutator 250 kilowatt generators joined in series and two pedestal exciters. The main exciter is 8.5 kilowatts at 110 volts and provide field current for both the high tension D.C. generators and for the field of the other exciter, the latter provides current for the field of the synchronous A.C motor. The speed of the set is 750 revs. per

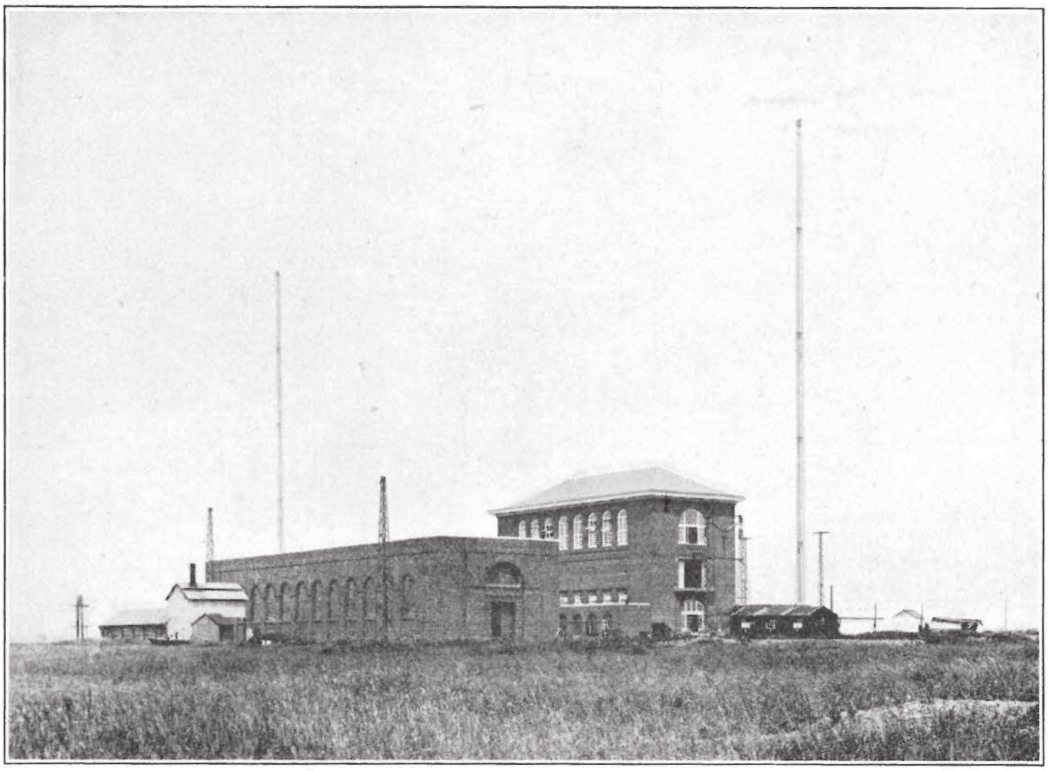


FIG. 2.—RUGBY RADIO STATION.

min. The five machines of each set are mounted on one bedplate, which is insulated from earth by being mounted on groups of porcelain insulators. The neutral point of the motor stator and the mid point between the two D.C. generators are connected to the base plate. By this means the potential of any portion of the set relative to the frames is limited to 3000 volts D.C. For convenience, the D.C. controls of each set are mounted on an auxiliary insulated base plate, which carries generator field rheostats and shunt field rheostats for the main exciter and the motor exciter. Both base plates of the set are connected together.

Each set can give an output of 500 k.w. at 6000 volts and one,

two or three sets may be joined in series. A separate starting cubicle and separate transformer is provided for each set; this avoids the use of insulated couplings between motors and generators.

Each main base-plate carries two high-speed circuit breakers, each connected in series with a generator armature. The breaker is set for instantaneous tripping at about 5 times full load current, and inserts a blocking resistance and at the same time trips the generator field contactor; on operation the contacts are fully opened in 0.02 sec.

To start the motors, the 12,000 volts A.C. is connected in star to the primary of the transformer delivering 1,270 volts between phases to the motor, a change-over switch then connects the

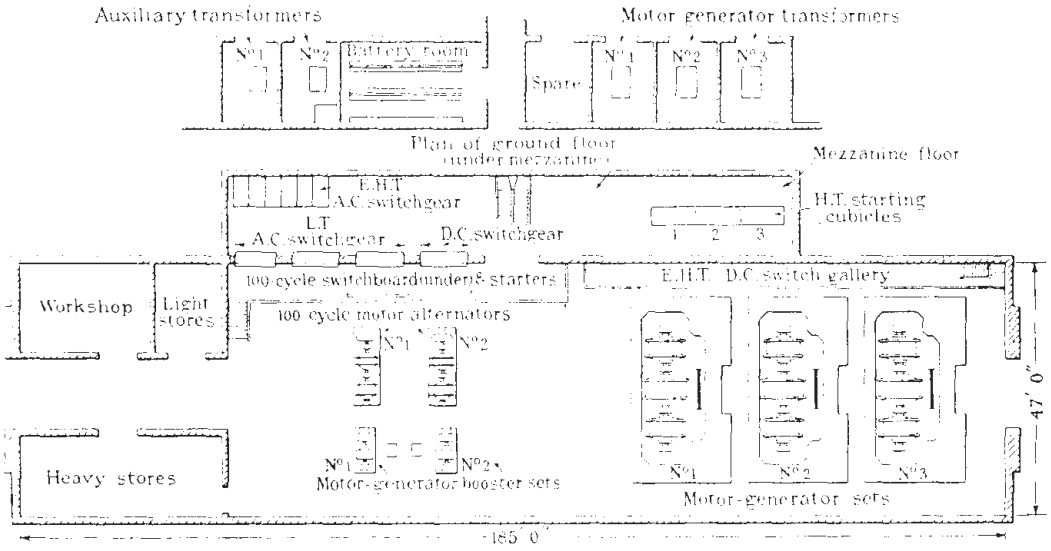


FIG. 3.—MAIN MACHINERY HALL.

primary in delta delivering 2,000 volts between phases for normal running. One of the sets was tested with 20 short-circuits at the makers' works and after installation two short-circuit tests were carried out with all sets in series and fully excited to a total of 18,000 volts D.C. with satisfactory results.

The 100 cycle frequency supply is obtained from a three-phase, 416-volt, 50-cycle synchronous motor coupled direct to a three-phase 416-volt 100-cycle 200 KVA alternator provided with a Tirrill regulator to limit A.C. voltage fluctuations.

Continuous current at 240 volts is furnished by means of 30 k.w. 416-volt induction motor-driven generator and booster sets in duplicate, in conjunction with a battery of 120 cells 200 ampere-hours. This D.C. supply is provided for excitation of motors, controls and emergency lighting.

Power for mast lift motors, lighting, pumps for air and water circulation, etc., is taken from the main low tension A.C. bus bars.

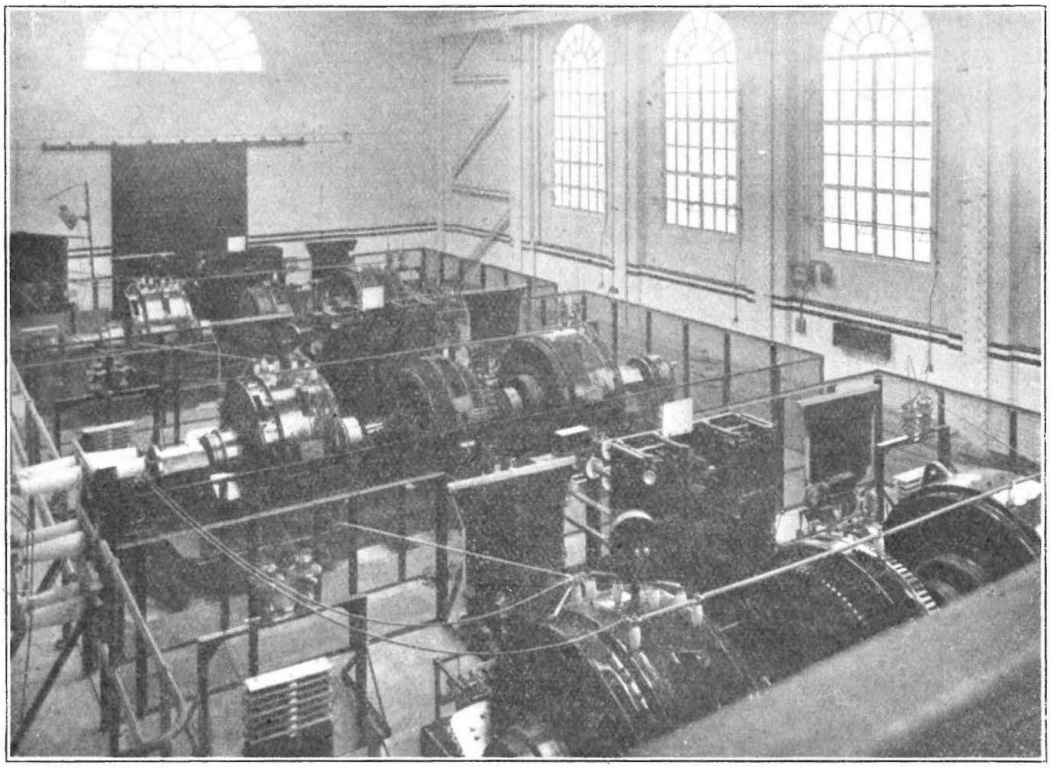


FIG. 4.—MOTOR-GENERATOR SETS.

HIGH FREQUENCY GENERATING VALVE PLANT.

The main wireless building is 103 ft. long by 42 ft. wide, and consists of two floors. The height of this building is 50 feet. (Fig. 5).

The high frequency generating valve plant utilises water cooled

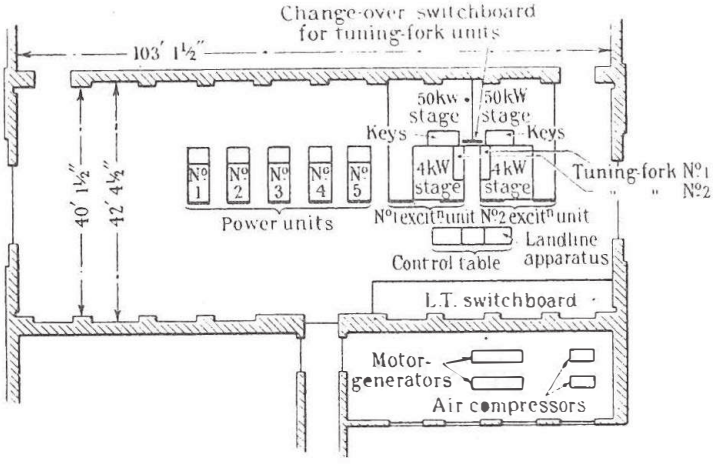


FIG. 5.—H.F. GENERATING PLANT LAYOUT.

thermionic valves and is capable of dealing if necessary with an output of 540 k.w. continuously under commercial conditions.

The general scheme of producing the high power is to generate oscillations of constant frequency at low power and proceed by definitely designed stages of amplification up to the maximum required for fully energising the aerial.

In order to reduce the possibility of interference from the high power transmissions and to permit the use of highly selective receivers, special precautions are taken to maintain a constant frequency. The primary oscillations are obtained from a tuning fork maintained in oscillation by means of a D.E.R. thermionic valve. The tuning fork vibrates at about 1,777 per second and

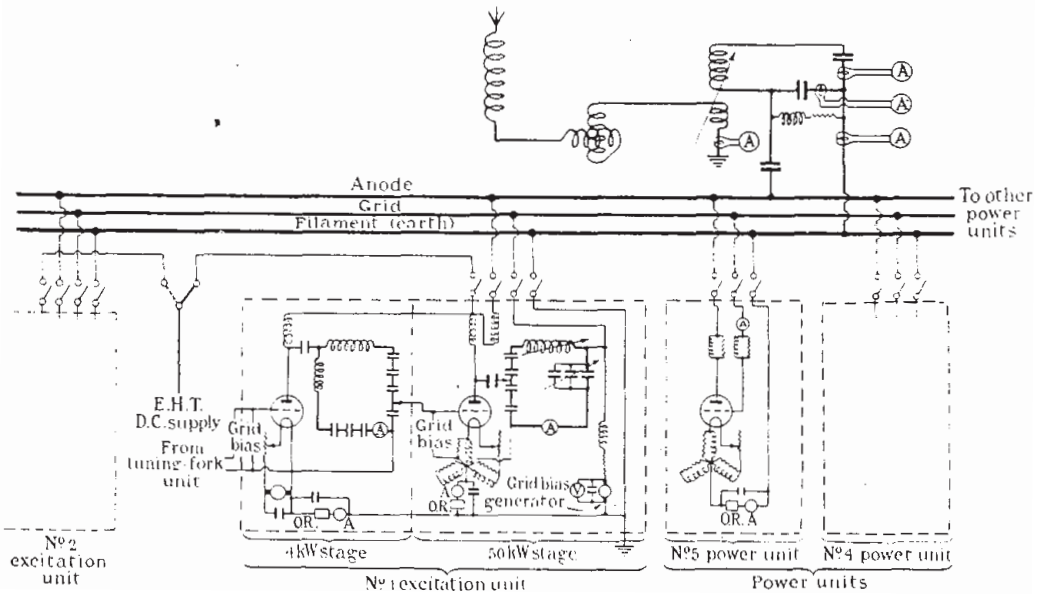


FIG. 6.—DIAGRAM SHOWING METHOD OF FEEDING H.T. D.C. SUPPLY TO POWER UNITS.

by means of a chain of small valves and filter circuits the ninth harmonic, a frequency of 16,000, is selected and amplified up to a power of about 100 watts. The stages in this chain of filter circuits and valve amplifiers are carefully copper screened from each other and from any external influences and constitute what is called the "Tuning Fork Unit."

The 100-watt output from the tuning fork unit at the station's signalling frequency is amplified three times before it is delivered to the aerial circuit, the successive stages being designed to deal with input powers of the order of 4 k.w., 50 k.w., and 1,000 k.w. respectively and giving output powers of 2 k.w., 30 k.w., and 540 k.w. respectively. These are referred to as the 4 k.w. stage, the 50 k.w. stage, and the "power units" respectively. Each stage includes a low decrement tuned circuit. The combination of

the 4 k.w. stage with the 50 k.w. stage forms the "excitation unit." The tuning fork units and excitation units are provided in duplicate and are interchangeable. All the stages are enclosed in high tension enclosures.

The final stage of amplification (the power units) is not provided in complete duplicate. The power station practice of having a number of units capable of being worked in parallel on common bus bars has been adopted. The principal advantages of this are that it permits an easy flexibility as regards power required for a particular transmission at a particular time of the day, it provides a simple method of repairing a faulty unit or of replacing worn-out

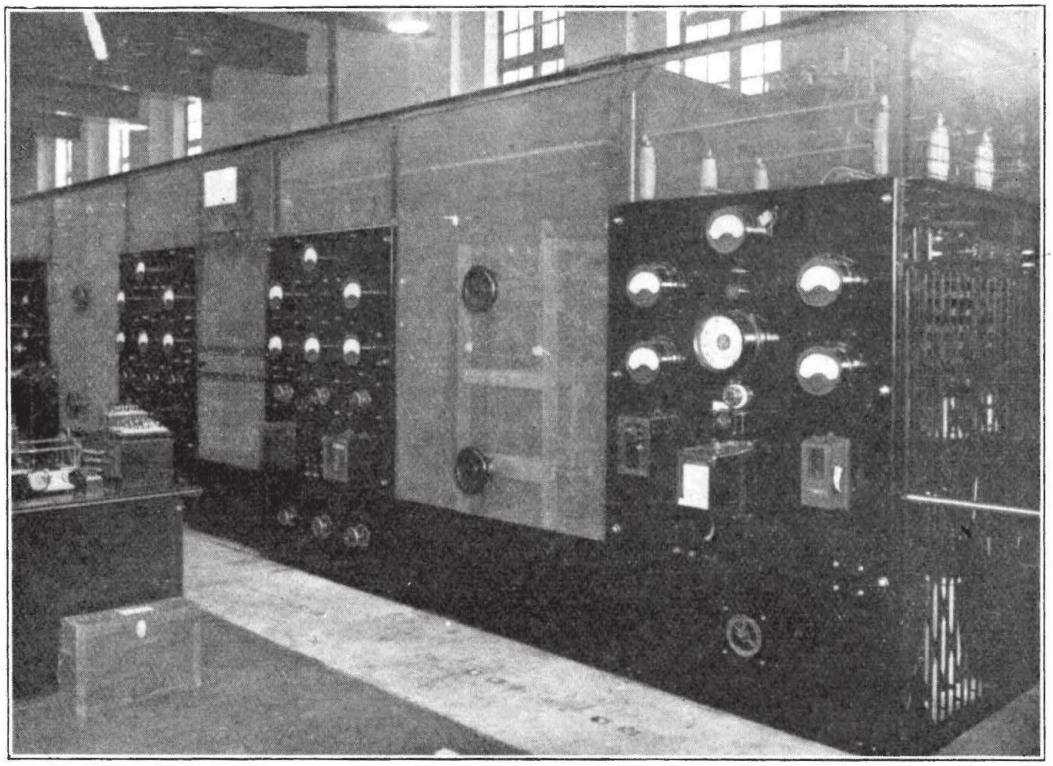


FIG. 7.—EXCITATION UNITS.

or faulty valves while the station is working. The installation can be easily adapted to provide two simultaneous transmissions on separate aerials and it gives facilities for testing different types of valves.

Fig. **6** is a schematic diagram showing the method adopted for feeding the high tension D.C. supply through a selected "excitation unit" to the power units by means of the bus bars and the method of paralleling the power units by means of the same bus bars. It will be seen that there are three bus bars running the length of the installation for anode, grid and filament (earth) respectively, and that to bring a particular power unit into opera-

tion in parallel with others it is only necessary to connect it to the bus bars by one 3-pole switch and light the filaments by means of the filament switch. In order to simplify this system of paralleling all apparatus proper to the final stage of amplification formed by the "power units" in use, such as anode choke, grid leak, etc., are placed inside the excitation units. The 4 k.w. stage employs glass valves and the 50 k.w. stage employs three water-cooled valves. The excitation units are screened from each other and the rest of the installation by an enclosure of copper mesh suitably mounted. (Fig. **7**).

The valves used in the power units are capable of dealing with

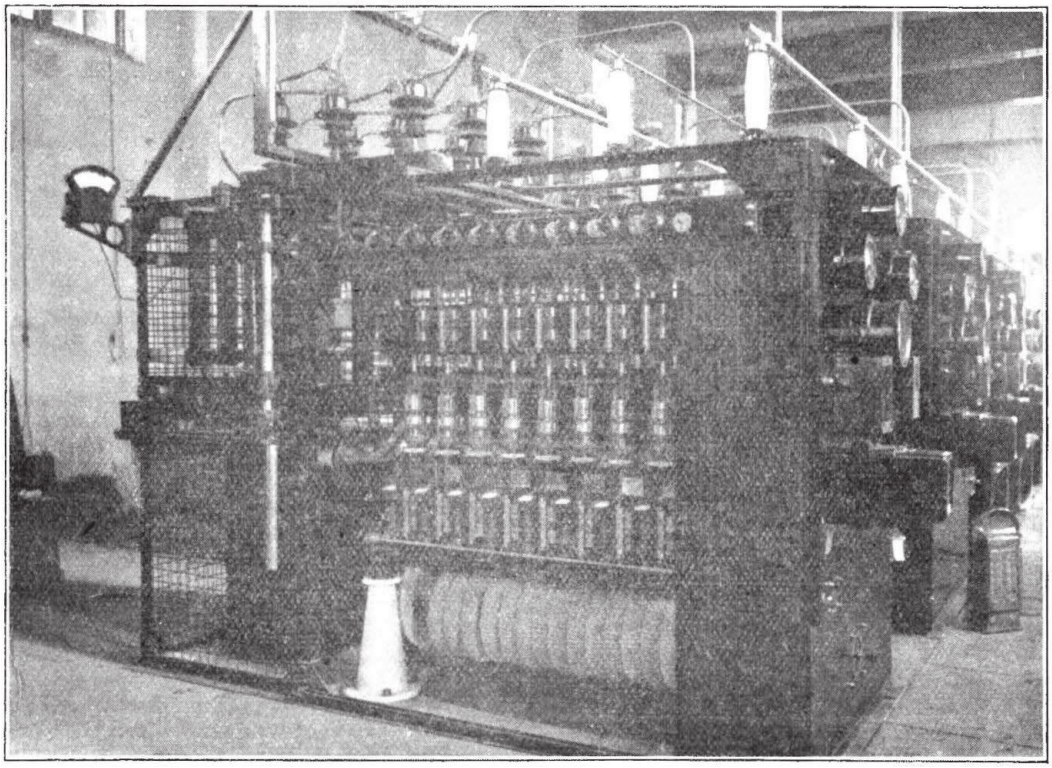


FIG. 8.—POWER UNITS.

an input of 20 k.w., of giving an output of 10 k.w. and continuously dissipating 10 k.w. when properly water-cooled and when operated at a D.C. anode voltage of 10,000 volts. The filament takes 41 amperes at 22 volts. These valves were made by The Standard Telephones & Cables, Ltd.

Five power units are provided. Each unit is equipped with 18 water-cooled valves, capable of an output of about 180 k.w. of high frequency power. With this equipment three power units will give an output of about 540 k.w. and leave two units spare.

The power unit (Fig. **8**) is a rectangular enclosure arranged with nine valves mounted on each side and a front slate panel con-

taining the meters. At the top of the power unit is the three-pole switch for connecting the unit either to the three bus bars or to earth. The valve panel contains the separate filament resistances, overload relays and other safety devices associated either with individual valves or the panel as a whole.

The distilled water used for cooling the valves is fed in each power unit to copper tube inlet and outlet headers through 30 ft. of 2″ diameter rubber hose mounted on a wooden reel at the lower part of the panel. From the unit the distilled water passes through metal pipes to a "cooler," the latter being cooled by means of a separate circulation of water obtained from a cooling pond. The

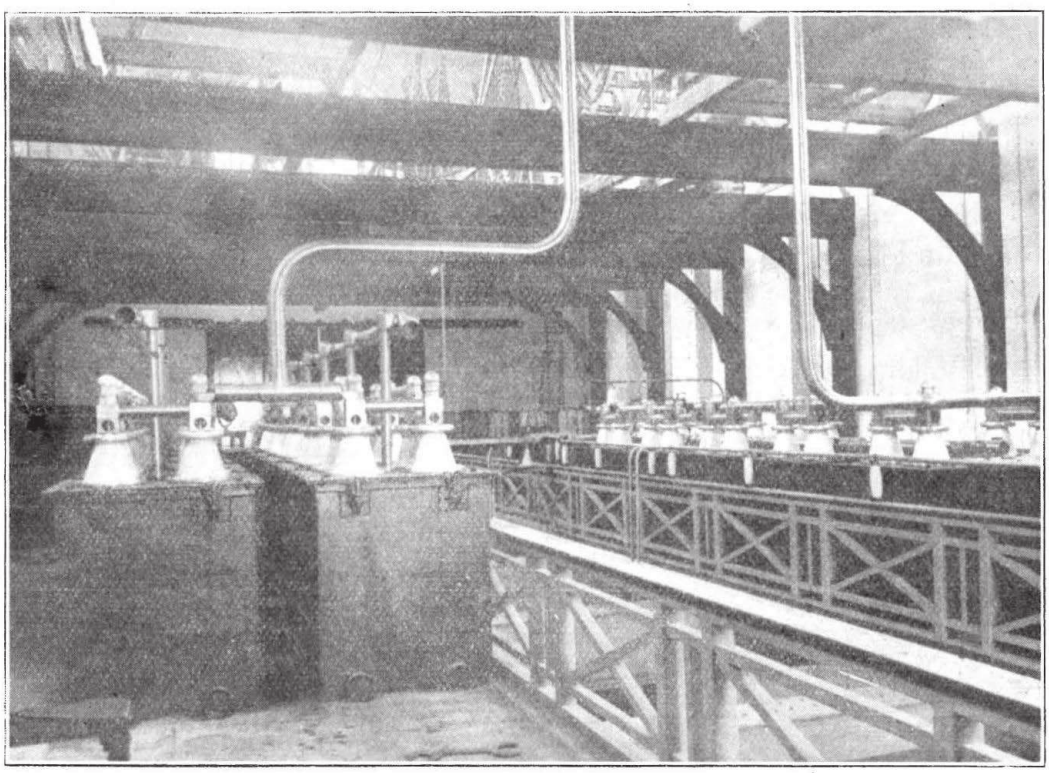


FIG. 9.—PRIMARY CIRCUIT CONDENSERS.

cooling pond has been built about half a mile from the station buildings and is filled from a stream which has been dammed and which runs through the site.

The high frequency output from the power units is fed into a primary circuit (Fig. **9**) made up of mica condensers immersed in oil and a tuning inductance made of cable containing 6,561 separately insulated wires, mounted in spiders of American white-wood. The coil is in the form of a hexagon with 7 ft. external sides. The actual measured resistance of the primary circuit at 16,000 cycles is .088 ohm.

The circuit is inductively coupled to the aerial circuit. The

aerial tuning coil, which has a maximum width of 14′ 6″, is made of similar cable to that used for the primary circuit, wound on whitewood spiders in the form of a hexagon with 7′ 9″ external sides. The measured resistance of the aerial tuning coil at 16,000 cycles is .11 ohm.

The method of keying the whole installation is by means of making and breaking the circuit between the output from the "tuning fork unit" and the input to the "excitation unit." The whole of the wireless installation was erected by Post Office workmen under the direction of Dr. Hansford and Mr. Raulkner.

The aerial is supported on 12 masts, each 820 ft. high, and is so arranged that it can be suitably divided at the leading-in points into two separate aerials, one much larger than the other. The whole aerial is used for telegraph purposes and using three power panels with 54 valves in use an aerial current of 740 amperes is obtained. With this current the voltage on the antennæ is about 175,000 volts.

For experimental telephony the smaller section of the aerial is used and the reduced telegraph aerial is then worked with an aerial current of about 600 amperes.

The masts and external work were described in an article by Mr. Walmsby, in Vol. 18, Part 1, April, 1925, of this Journal.

THE FELLING OF THREE RADIO MASTS AT DEVIZES.

Iron and steel will bend and bow,
Wood and clay will wash away,
Build it up with stone so strong;
Huzza! 'twill last for ages long.

From the Ballad of
"London Bridge is broken down."

On the side of a hill near the old market town of Devizes and a few miles from the ancient village of Avebury, six tall steel masts have formed a conspicuous landmark for many years. The number has now been reduced to three.

In the early part of September, three crashed to the ground, sacrificed on the Altar of Progress. It seems peculiarly fitting that this site should have been chosen for the scene of destruction; the offspring of the most modern branch of Engineering laid low amidst the ruins of the most ancient! Local antiquaries will tell you, if you are interested, of the great feats of those Neolithic Engineers who, at Avebury, ages before men learnt to use iron implements, built those huge circles of stone within whose confines

sun worshippers conducted their religious rites. They will speak with enthusiastic voice of the mighty deeds of the civil engineers of ancient times, who, to restrain the predatory encroachments of hostile Lords, excavated the great dyke that skirts the boundary of the Radio Station site. These deep ruts crossing the line of masts, mark the road made by Roman military engineers, and many an invading chariot has passed this way in the great days of old.

The trails of the engineer have left their mark unobliterated even by the passing of Time! Many other tales will be told, but

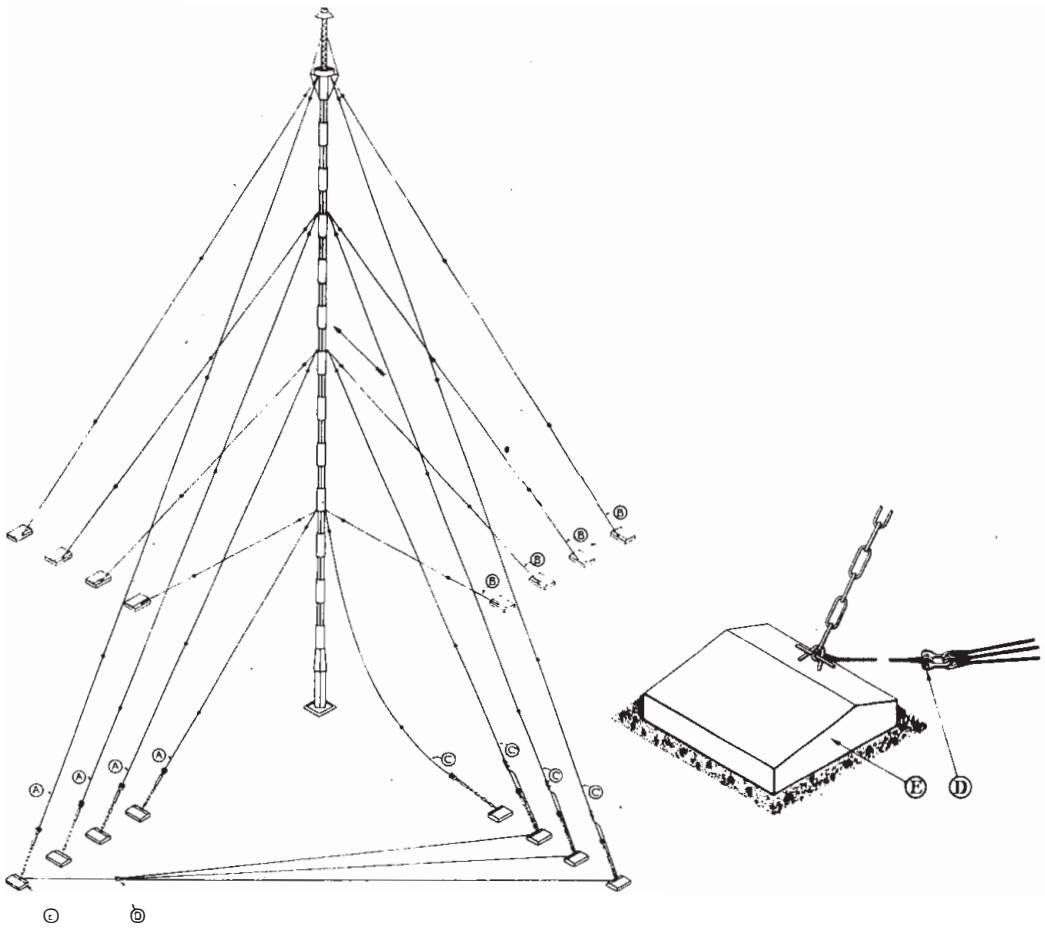


FIG. 1.—METHOD OF RELEASING STAYS.

if you pass down from the hill into the villages below the story you will hear most often concerns the sad passing of those 300 feet masts. Lest the details may be warped, the true account is given here. Each mast is held by 16 steel stay ropes, arranged in four groups. At the bottom of each stay and near the concrete anchor block, a "bottle" screw enables adjustment of stay tension. By turning the screw sufficiently, the stay becomes entirely detached from the anchorage. It might be thought that to cause a mast to fall, one merely has to screw round the "bottles" and so detach the stays

from the anchorages. The problem, however, is not so simple as this. The mast might fall at an inopportune moment and in a wrong direction. Trailing stays might whip some unfortunate worker. As the masts are composed of bolted sections, they could, of course, have been taken down piece by piece, starting form the top. Such a method, however, would have been too expensive. It would have been necessary to loosen many hundreds of bolts and to lower some thirty tons of material for each mast so dismantled.

The method adopted as being at once the cheapest, simplest and quickest is illustrated in Fig. 1. Four sets of stays are arranged at right angles. If one set of stays, those for example on the right

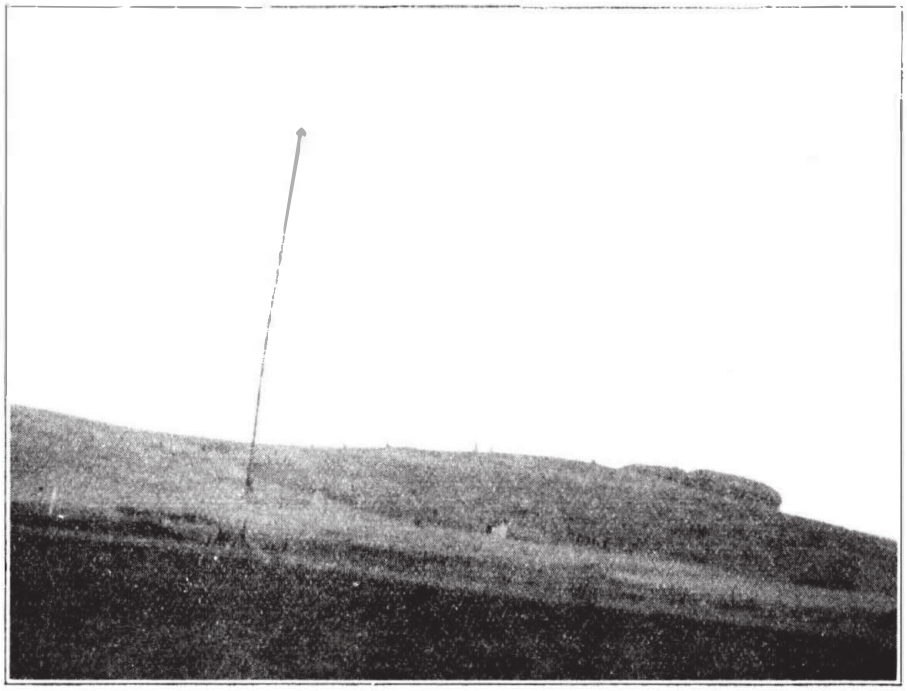


Fig. 2. A Mast Starting to Fall.

of the Fig., were released simultaneously, there would then be an unbalanced pull in the direction of the arrow, due to the tension of the stays immediately opposite. The ropes AAAA and BBBB, being fixed in one plane both to their anchorages and the mast, would prevent any movement of the mast except in the direction of the plane at right angles. Thus the mast would fall in the direction of the arrow. To ensure that all the tensions in one set of stays were released simultaneously, steel ropes were fixed temporarily to the three stays CCC above the "bottle" screws. The fourth and inner stay had previously been released, since this could be done with safety. Each of the three steel ropes was passed through an eye in its own anchorage and pulled out to a common

shackle at D. A steel sling was attached to the junction D and also to an inverted V-shaped bar fixed in the concrete block E. Thus one end of the sling held the three steel ropes, whilst the other was attached to the block at E. By tensioning each of the three ropes in turn and by removing the "bottle" screws at CCC, the pull of the three stays was resisted by the single sling. Some attention must now be given to the method of fixing the sling to the V iron. The sketch in the lower portion of Fig. 1 will explain matters. The terminating eye of the sling was passed through

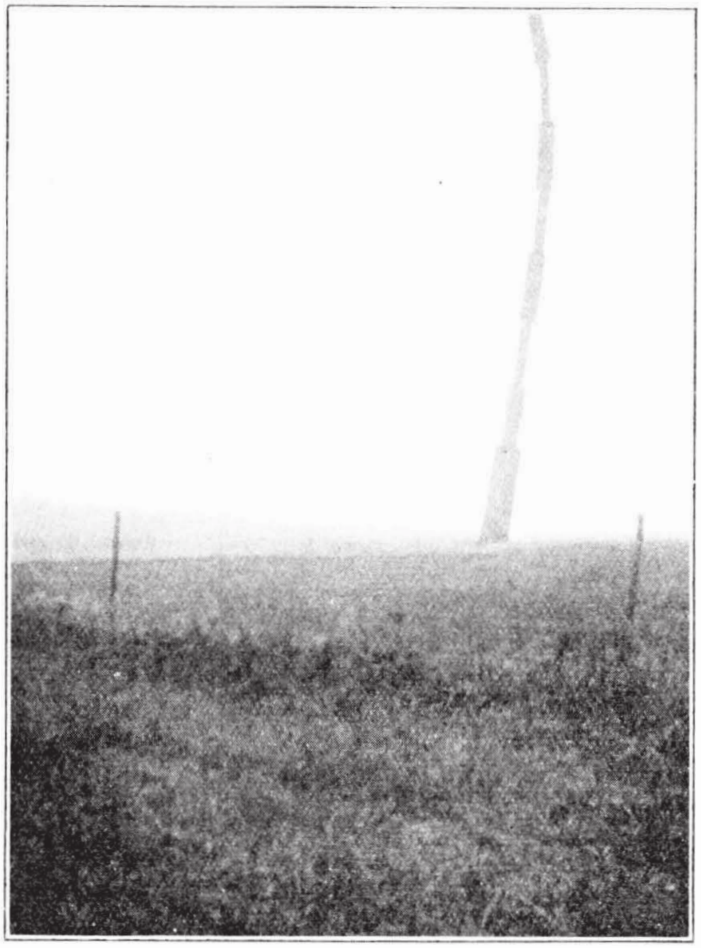


FIG. 3.—A FURTHER STAGE, SHOWING THE HUMP FORMING IN THE LOWER SECTION OF A MAST.

the inserted V. A short steel rod was thrust through this eye and allowed to rest on the legs of the V. In this way the pull of the three stays was communicated to the three ropes and a single sling, which was held firm by the thrust between the V and the pin. The nuts at the base of the mast having been removed, all was ready for the final act. Picture the scene as the anxious moment arrived to put the scheme to test! Holding a sledge hammer aloft, the executioner stands above the pin. A word of command and the heavy tool swings quickly down. The pin flies

out, the stays slays slacken and fall in towards the mast. For a moment the " stately and air-braving tower " remains erect, and then a great shout goes up, " She's falling ! she's toppling over ! " Slowly at first, but with ever increasing speed, the structure heels about the base. The higher sections of the masts describe a larger arc than the lower and thus accelerate at a greater rate. Unequally distributed forces are therefore brought into being, the loading progressively increasing from the base upwards. For a brief period the mast successfully resists these unequal forces, retaining a stiff steel backbone. Soon, however, the uneven contest ends and when about 10° of heel have been attained the great structure bends and bows in a curve of increasing curvature, the convex side upwards. The metal yields and on the tension side only large steel bolts stretch and snap. Then, with a thud

FIG. 4.—THE HEAD OF ONE OF THE MASTS.

heard miles away, the head crashes to the ground. The struggle is not quite over. Two thirds of the length of the mast lay stretched upon the ground, unsevered on the compression side from the remainder. At the base a great hump, 60 feet high, stands motionless for a few seconds, then slowly turns over to rest upon the ground. All is over ! And not one alone of the witnesses experienced " a pang as great as when a giant dies."

An examination of the first fallen mast revealed many interesting facts. To pull apart the nine bolts that failed in tension in the horizontal flange would necessitate a force of about 350 tons. Generally the section of the mast retained its original circular

section. At some sections, however, the bolts in the horizontal section remained intact and the material of the tubes failed. There is thus good evidence of the equality of strength of bolts and mast section. In a few places only the tube section had become elliptical due to the partial collapse of the walls on the compressive side.

No stays were damaged except in those cases where a blow had been dealt. The steel masts have been cut into small sections by means of an oxyhydrogen flame. And now the story of the passing of the masts is told. If, on that mid-September night when the last mast fell, you had chanced to pass by the great stones in the quiet village of Avebury, you would have seen —as the moon rose—small dark figures flitting about the ground,

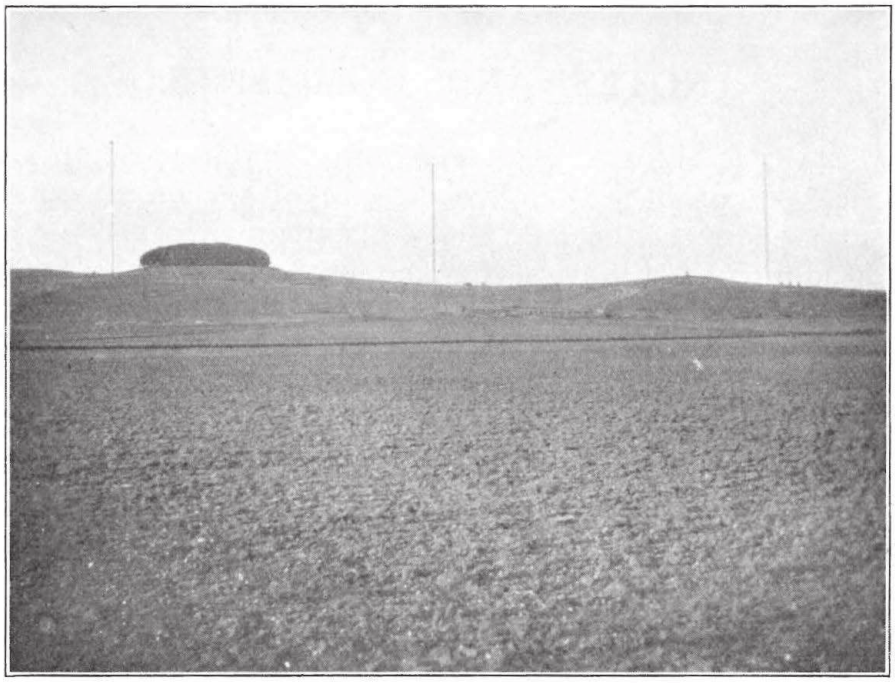


FIG. 5.—THE THREE REMAINING MASTS.

and heard a whispering sound rising and falling in gentle cadence. You and I, cold matter-of-fact engineers, would have dismissed the matter with some crude remark about shadows, and wind blowing leaves about. But the Poet, with wiser discernment, will tell you that these were no shadows caused by the rustling leaves, but elves and goblins jauntily capering around the great hoary stones, chanting joyously their triumphant song.

Iron and steel will bend and bow,
Wood and clay will wash away,
Build it up with stone so strong;
Huzza! 'twill last for ages long.

NOTES AND COMMENTS.

Mr. W. J. Medlyn, Superintending Engineer, South Lancs. District, occupies the chair for the current session at the North Western Centre of the I.E.E. In his chairman's address under the heading of "Electrical Communications, and the Spirit of Public Service," delivered at Manchester on the 2nd November last, Mr. Medlyn gave a very interesting review of the development and progress of the electrical industry generally and of electrical communications in particular.

The first important application of electricity was the introduction of the telegraphs in 1837. The Society of Telegraph Engineers was founded in 1871 and in 1883 it became the Institution of Electrical Engineers. In the course of his address Mr. Medlyn traced the rise of electrical engineering and said the electrical industry had become a public necessity, applied electricity and civilisation had become synonymous terms. He gave an imposing array of figures covering the plant and the capital invested in the business. In tracing the improvements in transmission introduced by the application of scientific methods, Mr. Medlyn gave some interesting facts and figures relating to the London-Manchester cable, completed and brought into use in April, 1922. The cable contains 160 pairs of 40 lb. conductors, 104 pairs telephones and 56 pairs telegraphs. By means of phantoms the 104 telephone pairs can give 156 trunks. The length of the cable is nearly 200 miles, and if it were not loaded and equipped with repeaters, the equivalent grade of speech now obtained would have been possible over some 13 miles only. To give equal speech over the 200 miles, copper wires weighing 400 lbs. per mile carried upon six lines of poles would be required, and an additional line of 56 wires of

150 lbs. would have been needed for telegraphs. These routes would have cost at least £1,500,000 more than the cable and to accommodate the lines it might be necessary to buy or rent a fenced-off strip of land, say, 20 feet wide, for a great part of the distance.

In the latter portion of his address Mr. Medlyn emphasised the necessity for peace in industry, and said we must have the co-operation of all grades of workmen in securing maximum production for the common good. He concluded as follows:—It is encouraging to note that the economic laws which govern our present life and civilisation are gradually becoming better known and appreciated by thinkers and leaders of all classes and all shades of public opinion, and the knowledge is spreading to all classes of the population. There is, therefore, good ground for the hope that the solution of our industrial problem will ultimately be found in the general recognition that, fundamentally, industry is a form of service to the whole nation; and, hence, good team work between all classes of organisers and workers engaged in the production and distribution of commodities is the best and surest way to improve the standard of living to the advantage of everybody concerned. Personally, I am convinced that the encouragement of this principle is the highest form of patriotism, because it is calculated to advance the industrial efficiency and the well-being of all members of the community and the general welfare of the British Empire.

In an address on "The Advancement of Electrical Engineering," Mr. Medlyn also delivered a useful and instructive exhortation to the students of the North Western Centre. At the outset he declared that the honour, the prestige and the progress of any body of men or association of men was the integral of the units composing that body.

He then passed on to consider the beneficent effects of maintaining a live interest in the particular work in hand and in the profession of electrical engineering generally. The value of proper perspective was emphasized, and it was pointed out that there was some danger in becoming so absorbed in one's own corner of Electrical Engineering as to lose sight of its relation to the world at large. In this way a narrow, cramped outlook would replace the breadth of vision which was essential for all positions of supreme control.

Mr. Medlyn then laid down the principle that the surest way to obtain material progress was to secure close co-operation between all classes engaged in the national industries. The resulting harmonious working would react to the benefit of the whole community, and consequently this spirit ought sedulously to be cultivated to replace the bitterness that so often manifested itself

between the various partners in the production of commodities. It was not easy, he said, to reconcile the many divergent views as to what was best for mankind, but there was a growing opinion amongst the majority of serious thinkers that economic peace between classes was as necessary to the future life of the world as political peace between States. But the object of all our work was to add to the amenities of civilization and the well-being of humanity in general.

A plea was here introduced for a sympathetic understanding not only of the minds of the workmen whom the young engineer was called on to control, but of the Chiefs whom he served. Adding, that it was only in this way that happy, harmonious, co-operative working, which was only another term for efficiency, could be achieved, he said the engineer of the future must, if he is to occupy a position of administrative control, not only know his work, but he must know his men. He must develop, along with his professional knowledge and experience, the knowledge of his fellow men. And all this must be correlated to the economics of his sphere of activity. The young engineer who kept those principles well to the fore and could " fill the unforgiving minute with sixty seconds worth of distance run," would not only command and attain the highest rewards of his profession, but he would attain the very highest plane of mental development and happiness in life.

In service to the community—which included his chiefs and subordinates—lay every material and moral advantage. He who served his day and generation best would surely best serve himself. His slogan should be " How best can I serve the community ? " *not* " How much pelf or kudos can I extort ? "

Mr. Medlyn next instanced the value of order and method, and suggested that deficiencies in this direction were generally due to disorderly thinking, and that this in turn was caused by lack of perspective in that the relation of the work in hand to the complete organisation was not fully appreciated.

The seriousness of errors of judgment in dealing with human problems was emphasized. Injustice rankled severely, and, like a contagious disease, spread around by contacts. The Electrical Engineering profession would advance at the rate that the coming generation advances, and he had, therefore, deemed it worth while to call specific attention to the things which would serve to develop the administrative powers of engineers. It certainly did not follow that every professional man had administrative ability simply because he was a professional man. These remarks were made from the point of view that in so many young engineers there was a tendency to treat with contempt the business aspect of their work, and Mr. Medlyn expressed the hope that he had

applied a small corrective of a wrong, but somewhat prevalent view point.

On the conclusion of the address the Chairman asked permission to discuss it. This Mr. Medlyn readily accorded, whereon twelve of the students took part in the ensuing debate. In general the very live discussion resolved itself into emphasis and extension of the principles laid down. Finally a very enthusiastic vote of thanks was accorded to Mr. Medlyn for one of the most interesting addresses with which the students had been favoured.

T.E.H.

FROM GAOL TO BROADCAST STATION.

The steady improvement in Irish conditions is reflected in the announcement that Standard Telephones and Cables, Limited, of London, have been commissioned by the Irish Post Office to supply a Broadcasting Station for Cork, and this will be located in the Gaol, now fortunately unrequired.

The Station will be of a similar type to that now in operation at Birmingham, but of an approximate 3 K.W. Geneva Rating.

The Annual Report for 1925 of the Rotterdam Municipal Telephone Service, which has recently been received, includes much valuable information. Rotterdam will be remembered as one of the first cities to make a trial of the ingenious automatic system manufactured by Messrs. Ericsson, of Stockholm.

The total number of lines on the 31st December, 1925, was 18,803, distributed among three exchanges—Botersloot, with 12,360; Korenaarstraat, with 3,943; and Vlaggemansstraat, with 2,500. At the last two exchanges, 1,905 and 2,081 lines respectively, are working on the full automatic principle. The number of stations at the same date was 29,881. Vlaggemansstraat exchange was opened on the 25th March, 1925.

No serious fault has occurred on the automatic equipment, the working of which is giving complete satisfaction. The new building for the Botersloot exchange, which is also to be converted to automatic working, has been commenced.

During the year under review the local traffic exceeded that for the previous year by 4.9 million calls, or 6.9%, as compared with an increase of 22.5% in 1924 over 1923. Traffic to and from other cities amounted to 3,225,545 calls—an increase over the previous year of 0.9%.

International traffic was responsible for several hundred thousand calls, the principal components being the following:—

With	Germany	244,780,	as against	224,353	in 1924.
,,	Belgium	122,848,	,, ,,	126,904	,,
,,	England	42,195,	,, ,,	24,189	,,
,,	France	2,569,	,, ,,	3,655	,,

For the busiest two-week period in the year—the week before and the week after Christmas—the average day calling rate per line was about 18 for the main exchange and 4 for the other two. During the same period the ratio of day to busy hour averaged about 8.

The number of public call offices numbered 113, and of coin-boxes in shops, etc., 88.

Requests for the correct time averaged 1,086 per week-day, 1,007 per Saturday, and 841 per Sunday.

The result of the year's working was a credit balance of nearly 874,000 florins.

In recent years sick absence has been steadily declining, the figure for the year under review being 3.09%.

These few particulars are culled from a large amount of interesting material in the report.

G.F.O.

CARRIER-CURRENT COMMUNICATION ON SUBMARINE CABLES.

The Journal of the American Institute of Electrical Engineers for October, 1926 (Vol. XLV., No. 10), contains a detailed description by H. W. Hitchcock, of the Southern California Telegraph and Telephone Coy., of a recent application of the principle of Carrier-Currents, which is of considerable interest.

Catalina Island, on the west coast of California, is separated from the mainland by a channel 23 nautical miles in width, and prior to 1920 the Island was not in telephonic communication with the mainland. A radio system was then established, the circuit being extended by wire between Avalon and Los Angeles. Owing partly to increasing interference from ships' transmitters and also to the growth of work, this circuit was replaced in 1923 by two single-conductor submarine cables, each of which was used as a single-wire telephone cricuit.

The further growth of traffic having necessitated additional channels, it was decided to instal the carrier system, and on the 15th May, 1926, six carrier telephone circuits were brought into operation on one of the cables. This cable now carries therefore seven telephone circuits and one telegraph circuit.

The arrangement is interesting, not only because it is the first case of application of carrier telephony to deep sea cables, but it is

the shortest carrier system (26 miles) in commercial operation. It provides more carrier channels than has previously been attempted, and it differs in several important respects from other systems.

METALLIC POLAR-DUPLEX TELEGRAPH SYSTEM FOR LONG SMALL-GAUGE CABLES.

The engineers of the Bell Telephone Company in the States have devised a complete telegraph system for use on the telephone toll cables of that organisation. Our old friend, and one time Secretary of the I.P.O.E.E., Mr. John H. Bell, with Messrs. R. B. Shanck and D. E. Branson, describes the system in a Bell Technical pamphlet. The following are some of the outstanding features:—Sensitive polarised relays, with closely balanced windings and in some cases with vibrating coils, are employed in the metallic circuit, and working currents of four or five milliamperes, obtained from 34 volt line batteries, while sufficient to operate the relays do not introduce appreciable disturbance in adjoining telephone circuits. Repeaters are spaced about 100 miles apart. Superposition is accomplished by the compositing method. The metallic system is suitable for providing circuits up to 1000 miles or more in length, the grade of service being better than that usually obtained from earth-return lines for such distances. About 55,000 miles of this type of telegraph circuit are in service.

NEUTRALISATION OF TELEGRAPH CROSSFIRE.

A Bell System Technical pamphlet describes the methods that have been adopted recently to neutralise mutual interference between parallel telegraph circuits, and by which, it is claimed, a reduction to 10 to 20 per cent. of the original values has been secured. The principle used is to connect circuits on which mutual induction exists by means whereby a neutralising impulse can be sent direct on the disturbed circuit at the same instant and with approximately the same value as the impulse produced by the mutual capacity coupling of the lines. This direct connection takes the form (*a*) of a small condenser fitted with a timing series resistance, joined at the beginning of the compensation circuit, (*b*) of a transformer with one winding in each battery to line circuit, or (*c*) in the case of phantom groups a balanced capacity Wheatstone bridge arrangement with the apexes joined to the compensation circuits of the composited telegraph circuits. Due to reduction of crossfire it is usually possible to secure a much better duplex balance after the neutralisers have been applied. The application of the anti-crossfire condensers, which have

appreciable capacity to earth, requires a different setting of the balance. It is said that no disturbance takes place in the circuits when parallel wires are idle.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENT.

The following works have been completed:—

Exchange.	Type.	No. of Lines.
West Hartlepool	New Auto	1120
Blackburn	Extn. Auto	1000
Farnworth, No. 10 C.B....	New Manual	500
Upton ,, ...	,,	420
Gravesend ,, ...	,,	1300
Bexley Heath ,, ...	,,	780
Shipley ,, ...	,,	1080
Camberley ,, ...	,,	740
Seven Kings ,, ...	,,	1370
Dumfries	,,	700
Bournemouth	Extn. Manual	1680
Romford	,,	320
Chester	,,	460
Mansfield	,,	220
Mountview	,,	1900
Trafford Park	,,	520
Leith	,,	260
West Bromwich Union ...	P.A.B.X.	40
Morris Cars	,,	70
Formans	,,	60
Bristol Times	,,	40
Phillips	,,	30
Transport and General Workers	,,	80
Gestetner, Ltd.	,,	40
Weymouth Corporation ...	,,	30
Producers Distributing ...	,,	30
Edmonton Guardians ...	,,	100
Rowe Bros.	,,	30
Ormerods, Ltd.	,,	30
Heywood (M/R)	,,	70
Burnley Corporation ...	,,	100
Manchester and Salford ...	,,	50
Wright & Sons	,,	30
Riseley & Sons	,,	30
Metal Agencies	,,	70
Equitable Trust	,,	50
Glasgow Housing ...		50
Rylands	,,	60

Orders have been placed for the following new Exchanges:—

Exchange.	Type.	No. of Lines.
East Finchley, No. 1 ...	Manual	3500
Colne, No. 10	,,	620
Blackley Co-op.	P.A.B.X	30
Calico Printers	,,	40
Heatons (Leeds), Ltd. ...	,,	30
Shell Mex (Strand) ...	,,	30
Droylesden Co-op. ...	,,	30
United Dairies, Ltd. ...	,,	50
Bowater & Sons	,,	30
Crawford & Sons ...	,,	60
International Combustion..	,,	70
Barrow, Hepburn & Gale.,	,,	60
Shell Mex (Leeds) ...	,,	30
Castner Kellner Alkali ...	,,	70
Shell Mex (Leicester) ...	,,	30
Stott & Smith	,,	30
Bury Corporation ...	,,	40
F. R. Simpson	,,	20
Greenock Corporation ...	,,	80
Jas. Hare, Ltd.	,,	30
Earl of Dudley's Works...	,,	70
Moss Gear, Ltd.	,,	40
Conolly's, Ltd.	,,	30
Plymouth Corporation ...	,,	210
Van Moppes & Sons ...	,,	30
J. Benn & Sons	,,	30
Watney, Combe, Reid ... (Tie Line Equipment)	,,	—

Orders have been placed for extensions to existing equipments as follows:—

Exchange.	Type.	No of Lines.
Carlisle, No. 10	Manual	400
Streatham	,,	1480
Tottenham	,,	1260
Weston-Super-Mare ...	,,	460
Willesden	,,	1700
Bradford	,,	560
Cambridge	,,	Rearrangements
Reigate	,,	1400
Palmers Green	,,	1640
Sevenoaks	,,	740

MR. F. L. HENLEY, M.I.E.E.,

Chairman I.P.O.E.E. 1925-26.

Mr. Frank Henley, Staff Engineer of the Test Section, who retired 11th September last, entered the service in 1881 at the Central Telegraph Office, where he soon became known as an expert operator. His skill resulted in his being sent to the Stock Exchange Office, where, on a famous occasion, he was one of four

men who, between them, despatched by Morse key 500 messages in one hour. Even allowing for the exceptional conditions at the Stock Exchange office, the feat was a remarkable one and it gained the thanks of the Postmaster-General.

In those days he was a useful boxer and a distinctly good swimmer, but his attachment to these sports did not interfere with the prosecution of his study of the pianoforte at the Guildhall School of Music, where he gained the School's Certificate of Merit.

MR. F. L. HENLEY.

An accomplished pianist he was greatly in request to play at staff social gatherings and concerts, and was obtaining much semi-professional work when a chance conversation led him to join the technical classes of Mr. (now Sir William) Slingo, and probably changed his whole career. Into the work of these classes he threw the energy and ability which have been the outstanding characteristics of his life, and in 1895 gained the 1st or Controller's prize, which is awarded to the student obtaining the highest aggregate

number of marks in all subjects. Probably as a result of this success he was sent, a few months later, to the Testing Branch of the General Factory, at Mount Pleasant. Here he joined Messrs. G. F. Mansbridge, W. H. Winny, H. H. Harrison and others and soon made good.

Entering the evening classes at Finsbury Technical College he took the 1st prize in Inorganic Chemistry, and continued with organic work, finishing up with laboratory tests of rubber and gutta percha. In 1903 the Testing Branch passed to the control of the Engineering Department; Mr. Henley was placed in charge and promoted to 1st Class Engineer. In 1904 he matriculated at London University and shortly afterwards having passed the Civil Service Commissioners' Examination for 2nd Class Staff Engineer, was transferred to headquarters and posted to the Examinations Section under Mr. Hartnell. His studies at Finsbury College continued, and in 1906 he gained the 1st prize in Advanced Mechanical Engineering.

In 1910 he was a delegate, with Major H. Brown, to the Paris Conference of Telephone and Telegraph Administrations, to which he presented a paper on "Some recent tests on Creosoted Poles," containing much interesting original matter. In 1919 he was appointed Staff Engineer in charge of the Test Section, in succession to Mr. J. R. Gall, who had been transferred to the Designs Section. The work of the Department and consequently of the Test Section was developing, and it fell to Mr. Henley to extend the Testing Branches in London and Birmingham, and to open a small testing station at Edinburgh. The branch at Birmingham, hitherto in charge of an Assistant Engineer, was now allotted an Executive Engineer, and the staff at both branches steadily increased to meet the ever increasing volume of work. Many new tests were introduced to meet the requirements of new items, *e.g.*, audio frequency bridge test, special automatic testers, etc. Paper-core submarine cables were introduced and much testing and consultative work was undertaken for the various Dominions Governments. As showing the increase of work between 1919 and 1926, it may be mentioned that the value of the stores tested in 1925-26 was double that of 1919-20.

In 1921, Technical Instruction VIII., on his initiative, was compiled under his supervision, and issued to the Staff. In 1923 he published, through Messrs. Longmans, his Telephone Manual, entitled "The Inspection and Testing of Materials, Apparatus and Lines," a valuable handbook for post office men employed on inspection duties. Some reference must be made to the vast amount of labour and time expended on Committees of one kind or other. Mr. Henley served on very many of these bodies, among them being :—

The Interdepartmental Committees No. 2, Materials; No. 5, Power Cables; No. 6, Telephone and Telegraph Wires and Cables.

As chairman of the last-named, he represented it on the B.E.S.A. Committee which issued Standard Specifications Nos. 174-184.

The Committee of the Department of Industrial and Scientific Research on the Preservation of Timber.

The Committee of the British Electrical and Allied Trades Research Association on Composite Insulating Materials, Mica, etc.

The Committee of the B.E.S.A. which published the Standard Specification for Vitrified Ware Pipes.

Major McClintock's Committee on Fire Emergency in the Central Telegraph Office.

This gives but a slight idea of the Committee work he performed, for he did not spare himself, and made important contributions to each and all of them. From the time he took charge of the Section, in 1919, his relations with the Staff were of a most friendly nature. He always felt his responsibility for them and used all legitimate means to further their interests. Personally, I found him an understanding and sympathetic chief and a good friend. It may be said that he knew what was good, did justly, and never strained the quality of mercy.

He has always retained an interest in sport and has generously marked his retirement by presenting a silver cup to be competed for annually by football teams chosen from the London and Birmingham Testing Branches, and this, and the now well-known Telephone Manual, will help to keep his memory green.

Mr. Henley is married and has two daughters; he suffered the grievous loss of his only son in the war, in 1916. His positive and striking personality will be greatly missed. He takes into retirement the warm good wishes of his many colleagues and friends, and, judging from his excellent health and vigour, it is reasonable to hope he has many pleasant years in front of him. Mr. Henley is prominently engaged in church work and his recreations include higher mathematics and mental and moral philosophy.

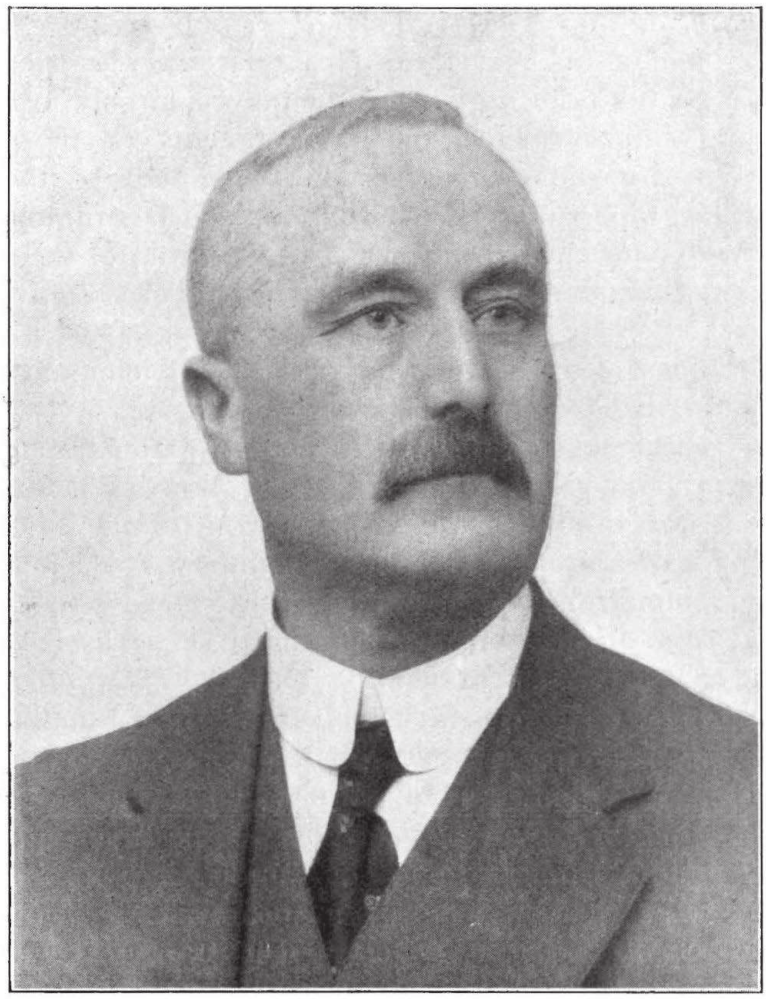
F.H.B.

MR. EDWIN LACK, M.B.E.

By the retirement of Mr. Lack, under the age limit rule on the 12th September, the Department lost one of the best known figures in the English Telegraph world.

In January, 1882, he was appointed S.C. & T. at Hull—an

office which is notable for the number of men who have joined the Engineering Department. It is thought indeed that Hull has furnished more officers for the Engineering Department than any other city or town in the United Kingdom at which there has not been a Superintending Engineer's Headquarters. One can recall the names of Harrison, Smart, West, Youngs, Johnson, McInnes, Tinsley, Richardson, Anson, Burton, Statters, Platt, Hammond, Vickery, Tanner, Kemplay and others who have attained high rank in the Engineering Department.



MR. EDWIN LACK, M.B.E.

Mr. Lack took a great part in the formation of electricity and magnetism and telegraphy classes, of which he proved a very successful teacher, and several of the men whose names are mentioned above were his pupils. He also took an active part in the formation of the Signal Section of the Hull Rifle Volunteers (a rare luxury in those days) and became its first Corporal.

He joined the Engineering Department as a Relay Clerk in

November, 1893, and after service at East Dean and Lowestoft was appointed Second Class Engineer at Dundalk in November, 1899. Like other men who have had service in Ireland, he brought back not only experience but a fund of good stories. He was transferred to Brentwood in December, 1900, to Chelmsford in December, 1904, and appointed First Class Engineer in London in November, 1906, where he had charge of the Victoria Section and afterwards of the combined Victoria and Mayfair Sections. He was appointed Staff Engineer, Second Class, and attached to the Telegraph Section in April, 1909, and Assistant Staff Engineer in July, 1911.

The whole of his service at Headquarters was spent in the Telegraph Section, during which time he was largely instrumental in devising improvements and developments in the telegraph service. In 1910 he was appointed a member of the Anglo-German Telegraph Commission, which met at Berlin, and was the Engineer-in-Chief's representative at the opening of the cable laid by the Post Office for the Anglo-Norwegian Telegraph Service in the same year. He introduced the present system of morning testing of lines, after serving on the Testing Committee under Mr.—afterwards Sir William—Slingo in 1913-14.

At the outbreak of the Great War, Mr. (afterwards Lt.-Col.) Booth was appointed Assistant Director of Army Signals, and Mr. Lack took charge of the Telegraph Section for the whole period of the War. Among other things, he was responsible for equipping submarine cables from Beachy Head to St. Nazaire (France), from Peterhead to Alexandrovsk (Russia) and the Imperial cable from Penzance to Halifax, Nova Scotia. He established duplex repeaters at Dieppe for duplex Baudot working for the service between London and Paris, and equipped with telegraph apparatus Lord Haig's train for his movable headquarters. During the Irish troubles he carried out the transfer of the Direct United States Cable Office at Ballinskelligs.

For his services during the war he had conferred on him the honour of a Member of the newly created Order of the British Empire in January, 1918.

Among other improvements he arranged the application of the Gulstad vibrating relay arrangement to the Post Office standard relay, now known as the "G" Relay. By this arrangement many circuits which formerly had to be worked through repeaters can be worked direct.

In 1924 he went on two occasions to the West Indies in connection with the laying of the new telegraph cables between Turks Island, Barbadoes, Trinidad, and Demerara.

In the installation and adjustment of troublesome apparatus Mr. Lack is an acknowledged master, and Telegraphists or En-

gineering Officers in difficulties always received from him not only capable but also the most friendly assistance. He never put on the attitude of superior knowledge, and his great experience and skill were always at the disposal of his colleagues.

He was particularly fond of cricket, boating, fishing, etc., and in his later days has taken great interest in the game of bowls.

On his retirement he was presented with a 3-valve Radio set with loud speaker by his colleagues at Headquarters, and with a travelling bag by colleagues (chiefly old pupils) in the North Eastern District.

His genial presence and friendly comradeship will be greatly missed, and all his friends will join in wishing him and Mrs. Lack many years of comfort and good health in his retirement.

T.B.J.

H. P. FEW.

On 14th September passed away, after a lengthy illness which had involved his premature retirement, Herbert Percival Few, late Staff Officer, Engineer-in-Chief's Office, aged 50 years. The interment took place at Pinner Cemetery.

He entered the Engineering Department in 1902 from the London Postal Service and was engaged principally on Staff Establishment and accounts work in the Headquarter office. Although of a retiring disposition he was known and esteemed for his sterling qualities by a large circle of office colleagues.

Outside the Engineering Department he is perhaps better known by his text books in technical Telegraphy and Telephony and Mathematics, which works have found their way into all parts of the British Empire.

He leaves a widow and a son of 18 years of age.

ALEXANDER E. KEITH.

Telephone engineers of all grades have received the news of the passing of Alexander E. Keith with universal regret. He died on September the 24th last, at Chicago, in his 66th year.

Automatic Telephony has lost an outstanding personality and a real pioneer, as Mr. Keith was associated with the primary development of the Strowger system in America as long ago as 1893. From that time onwards he has consistently directed his energies to the perfection of machine switching in telephony, and his name has been identified with many of the major advances in this extensive field.

In the course of his long career Mr. Keith has filled many important engineering and executive posts; it is in no small

measure due to his efforts, that the Automatic Electric Inc. of Chicago, is the vast and flourishing organisation it is to-day. In this country he is best known by the " line-switch " bearing his name. Prior to the invention of this earliest " preselector " type switch by Mr. Keith, the Strowger system, on its original basis of " one connector per subs. line," was little more than an interesting mechanical experiment. The cost of providing a telephone service on the basic Strowger two-motion switch plan, was prohibitive. The Keith Line Switch revolutionised this, and machine switching was thereby enabled to commence its long, uphill struggle against prejudice and convention, with its most serious handicaps, that of excessive initial plant costs, practically removed at the outset. Competition with the many manually operated systems that held the arena with such apparent security became an accomplished fact. It can, perhaps, be claimed that this invention of Mr. Keith is the most important contribution the science of automatic telephony has yet received, despite the fact that it was one of the earliest.

Undoubtedly, many of our modern conceptions, such as trunking and grading, have their genesis in this the first preselector switch.

Simplicity is an attribute of genius—in invention, as in other things, and this is aptly exemplified in the Keith line switch. Just a line relay, a two-coil, single core electromagnet, attracting an armature carrying a pivoted plunger to engage the bank contact springs. Quite simple, almost elementary, but it did its job and is, at the present time, doing it well. Nearly twenty thousand " Keith " Line Switches are " plunging in " on the service of British telephone subscribers. At least half of this number have stood the acid test of working conditions for nearly ten years. And the Keith Line Switch is not quite so prehistoric as many of us may imagine. What is the two-step relay but a variant of the combined pull down and bridge cut-off? The principle is there, if the application be different.

The Keith Line Switch had its limitations. Mr. Keith himself was among the first to acknowledge them and to suggest alternatives. It has now been supplanted by the rotary type of preselector. Progress in a healthy industry inevitably imposes revolution of this nature. The cherished notions of to-day become the history of to-morrow. This is but the natural outcome of a ceaseless striving after perfection. It was this that produced the Keith Line Switch, and laid the foundation of Automatic Telephony as we know it to-day.

A fitting tribute to the memory of A. E. Keith is the fact that the experience which has led to the evolution of the Director, the Discriminator, and other of our modern complexities has been

gained largely on installations equipped with the Keith Line Switch. F.J.G.

Mr. L. M. Ericsson, the Swedish Telephone Engineer and Manufacturer, died on Friday, the 17th December.

Mr. Ericsson was the founder in 1876 of the organisation bearing his name and therefore was the World's pioneer manufacturer of the Commercial Telephone. He commenced business in a very modest way, but being a man of keen intelligence and foresight his business rapidly grew until to-day it is the largest telephone manufacturing concern in Europe. In this and other Countries the Ericsson concern employs many thousands of workpeople.

THE ROMANCE OF THE FORTY THIEVES.

(MODERN VERSION).

Ali Baba in years gone by uttered the magic words "Open Sesame," and behold the treasures of the world were revealed to him.

The romance of the modern forty thieves and the treasure they found is well worth recording, and it will have served its purpose if it stirs the young men in the Post Office Engineering Department to the chances open to them and the positions in the service to which they can attain if they only work for them.

Just over three years ago the Research Section, Dollis Hill, required officers for Main Cable Testing work. The question was: "Can we obtain suitable men from the rank and file?" The answer was: "Try." An examination* was held and about 300 young men sat for it. Of these, 40 were chosen—most of them Unestablished Skilled Workmen and Youths—and they set out for Dollis Hill to commence the training course.

There were tall men, small men, stout men and thin men; in one corner could be heard the Cockney dialect, in another the Yorkshire, in another the Lancashire and in another the Scottish —a modern Babel indeed—but there was one thing these young men had in common, and that was the ambition to succeed.

The class started in July 1923, and the fact that these young members of the staff were very keen on their work soon drew attention from other members of the staff and some one in jest

* Messrs. A. B. Morice and A. Morris. "The Training of Officers of the British Post Office Engineering Department in Precision Testing of Underground Cables": Journal *P.O.E.E.*, July, 1926, Vol. 19, Part 2, p. 196.

nicknamed them "The Forty Thieves." Thieves, in a sense, because knowledge was the plunder, and, as will be seen later, the spoils were very evenly divided. The name "Forty Thieves" has endured, so much so, that individual members of the class are now labelled as one of the "Forty Thieves."

At the end of a seven weeks' course, 23 members of the class were selected for the work on hand, and the remaining 17 were—after a period of practical training—returned to their districts to act as reserves. All members of this class were given the temporary rank of Acting Inspector.

Three years have passed and these men—the greater number still on the best side of thirty—are now for the most part in the major ranks of the service.

Here are the figures:—

Assistant Engineers	14
Inspectors	12
Acting Inspectors	4
Returned to District	2
Traffic Appointments	2
Left Service	6
	40

I am sure that now the tale has been told there is no one but will agree there is some romance even in this practical service of ours. The chance still remains—examinations for Inspectors and Assistant Engineers are still being held—and every eligible youngster should try to follow the footsteps up the hill and prove that there are more good fish in the sea than have ever been taken out of it.

No. 5.

LONDON DISTRICT NOTES.

DURING the quarter ended September 30th, 1926, the number of exchange lines, internal extensions and external extensions provided and recovered were as follows:—

	Exchange lines.	Internal Extensions.	External Extensions.
Provided ...	9,063	5,276	916
Recovered ...	3,256	3,088	531
Net increase ...	5,807	2,188	385

External Construction.

Mileage Statistics.

During the three months ended 30th September, 1926, the following changes have occurred:—

Telegraphs.—A net decrease in open wire of 52 miles and a net increase in underground of 326 miles.

Telephones (Exchange).—A net decrease in open wire (including aerial cable) of 156 miles and a net increase in underground of 42,481 miles.

Telephones (Trunk).—A net decrease in open wire of 2 miles and a net increase in underground of 1,199 miles.

Pole Line.—A net increase of 97 miles, the total to date being 5,549 miles.

Pipe Line.—A net increase of 447 miles, the total to date being 7,233 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	25,120
Telephones (Exchange)	1,801,700
Telephones (Trunks)	63,853
Spares	69,504

Internal Construction.

New Exchanges.

Rodney Exchange, C.B. No. 1 (Peel-Connor), of 3,900 capacity fully equipped, was opened on October 2nd to serve a portion of the Walworth Area. *Reliance* Exchange is being accommodated on this equipment temporarily.

The old Kellogg Exchange at *Battersea,* with its relief exchange of *Latchmere,* was replaced by a 10,000 line C.B. No. 1 type Exchange (General Electric Co.) on the 16th October. The present fitted capacity is for 1,740 direct lines.

A C.B. No. 10 Exchange with 6-panel multiple, installed by Messrs. Siemens, replaced a magneto exchange at *Bexley Heath* on November 6th. It is a 3,000 line switchboard, the present equipment being for 1,100.

A new C.B. No. 1 Exchange has been installed at *Burgh Heath* by Messrs. Ericsson. It has an ultimate capacity for 4,500 lines; the present fitted capacity is for 1,740 direct exchange lines.

Seven Kings was opened as a hypothetical Exchange on Ilford in July. The new Exchange (Siemens C.B. No. 10, 1,500 lines) was opened on December 2nd.

Wallington New Exchange (C.B. No. 1) is nearing completion and will be opened in the first quarter of 1927. This is a

Peel-Connor Exchange and the present equipment is for 2,900 lines.

Automatic Exchanges. Progress is being made with the installations at Mechanical Tandem, Bishopsgate, Holborn and Sloane.

C.C.I. The group of Coder Call Indicator Positions in the 1st Zone, comprising Addiscombe, Thornton Heath and Croydon Exchanges, have been tested out in readiness for use on the opening of the Mechanical Tandem Exchange at Holborn.

Hall Multi Coin Boxes. Coin Boxes of this type are gradually taking the place of the Coin Collecting Boxes in the Inner London Area. Call Offices in the Paddington and Gerrard Exchange Areas have been converted, and Royal and Museum Areas are in hand. It is expected that 2,000 of the Prepayment boxes will be fitted within the next year.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

ELECTION OF COUNCIL FOR YEAR 1926-7. REPRESENTATIVE OF ASST. & 2ND CLASS ENGINEERS.

THE result of the election in respect of the above representative is as follows:—

*Hay, P. G.
Gear, W. J.
Gray, H. C.

The names are arranged in the order of votes polled and the successful candidate is indicated by an asterisk.

LOCAL CENTRE NOTES.

LONDON CENTRE.

SESSION 1926-27. (FIRST HALF).

THERE has been a steady increase in the Membership during the current year, and it is pleasant to record that there was a gratifying response to the application for papers for the general meetings.

The Session was opened by an address from the Chairman, Lieut.-Col. E. G. Lee, M.C., B.Sc., M.I.E.E., the subject chosen being "Transatlantic Telephony." As was anticipated, the attendance reflected the great interest which is taken in Wireless

Telephony in these days, there being 202 present. The address, which dealt with up-to-date developments of Radio Communication between this country and America, was supplemented by slides showing the Rugby Wireless Station and some highly interesting curves illustrating the effect of atmospherics on audibility at different periods of the day.

On the 9th November, Mr. W. Day, M.I.E.E., read a paper on "Phases in Automatic Telephony." The paper dealt with the subject under the following headings:—

Numbering schemes in Multi-Office Areas; Fundamental considerations concerning traffic discrimination; Statement of Principles embodied in existing types of discriminating switches; Common defects; Characteristics of an ideal discriminator; a P.O. Traffic Discriminator for Director areas; A limit to the economic use of common plant; Notification of abnormal plant conditions; Nature and effect of irregularities; Methods of control and indication in Main Exchanges; Transmission of emergency alarms from unattended Satellites to their Parent Exchange.

In view of the popularity of automatics there was no dearth of speakers, some of whom provided the light relief so necessary in a weighty subject of this nature by allusions to the word "phase" and its various definitions. It is not at present proposed to print this paper, but a copy has been deposited with the Librarian for reference by the Members.

On the 14th December Mr. H. Kitchen, M.I.E.E., read a long-awaited paper on "Economics of Line Plant Provision." This highly interesting contribution dealt with such subjects as comparative capital and annual costs for underground and overhead systems, apparatus for thrust boring, contract works, automatic layouts for multi-office areas, determination of practical telephone centres, and the controversial question of "teeing." A spirited discussion was opened by Capt. J. G. Hines and representative opinions were obtained from Major H. Brown and others. Mr. W. B. Crompton gave an explanation of the simplicity of the "teeing" arrangements. It is unfortunate that the discussion had to be somewhat curtailed owing to the late hour.

In continuance of its policy, the Committee have arranged for a series of informal meetings, and the first of these was held on the 26th October, when Mr. G. F. O'dell, B.Sc., A.K.C., M.I.E.E., opened a discussion on "The growth of American Influence in the Post Office." The record attendance at this meeting must have been very gratifying to the author. May one dare to suggest that the large attendance may not have been wholly due to the popularity of Mr. O'dell, but might in some measure be explained by the fact that the subjects dealt with represented only about 10 per cent. telephones?

The second informal meeting was held on November 23rd, when Mr. W. Dolton, M.I.E.E., offered some observations on "Electrolytic Damage in the London District." It is unfortunate that so many members were unable to be present at this meeting as Mr. Dolton had evidently taken a great deal of trouble to prepare his subject matter and erect the demonstration apparatus, the result being a highly interesting and instructive address. It is, however, very nice to record that the majority of the members present entered keenly into the discussion.

Arrangements were made for a visit to the Standard Telephone Company's Hendon Works on the 28th September. The number of members wishing to attend was so large that a ballot was necessary, and the successful 140 had a most enjoyable time. The party were conducted round the Works in a manner which reflected great credit on the Standard Company's organisation. The Committee would like to take the opportunity of thanking the Managing Director and his Staff for the excellent programme arranged for the visitors.

It is proposed to visit the G.P.O. Holloway Factory early in January.

F.W.F.

EASTERN CENTRE.

The following is an extract from a paper read before the Eastern District, I.P.O.E.E., Local Centre, by Mr. C. J. Jones, Officer-in-Charge Fenny Stratford Repeater Station, at the Majestic Cinema, Fenny Stratford.

The paper was excellently illustrated by slides.

Mr. J. F. Lamb, M.I.E.E., Superintending Engineer, presided, and was supported by Major Bachelor, D.S.O., Assistant Superintending Engineer, Mr. A. J. Sharpley, Sectional Engineer, St. Albans, Mr. W. Cruickshank, M.I.E.E., and Mr. E. S. Ritter, D.F.H., A.M.I.E.E., and other officers from E.-in-C.'s office, Mr. S. W. Bassett, Technical Section, Cambridge, and many other engineers and officers of the Eastern District.

A very intelligent interest was displayed by the Eastern District and a good attendance resulted, approximately eighty members and associates being present.

Mr. Lamb proposed a vote of thanks to Mr. C. J. Jones, who suitably replied.

Owing to lack of time no discussion took place, but the meeting adjourned to the Repeater Station, where one of the engines was started to enable the party to watch operations on the spot. The party was made up into four groups and conducted round the station, while a detailed explanation of the plant was given by Mr. C. J. Jones, ably assisted by three of his staff.

The photos are by Mr. J. E. Statters, Messrs. Bed.'s Times Publishing Co., and Mr. W. G. Berrill, a member of the Repeater Station Staff.

Fenny Stratford Repeater Station.

By C. J. Jones.

Repeaters were first installed at Fenny Stratford in the year 1919. The installation was carried out by the local staff, under the supervision of the E.-in-C.'s Office, Telephone Section. These repeaters were known as the 21 type, *i.e.*, "Two-way, one valve, one stage." They were installed in the old Main Line Test Hut, and the circuits in which they were inserted were 7 phantom unloaded circuits in the TSX—BM—LV cable. These circuits have since been loaded and the cable put straight through without repeaters.

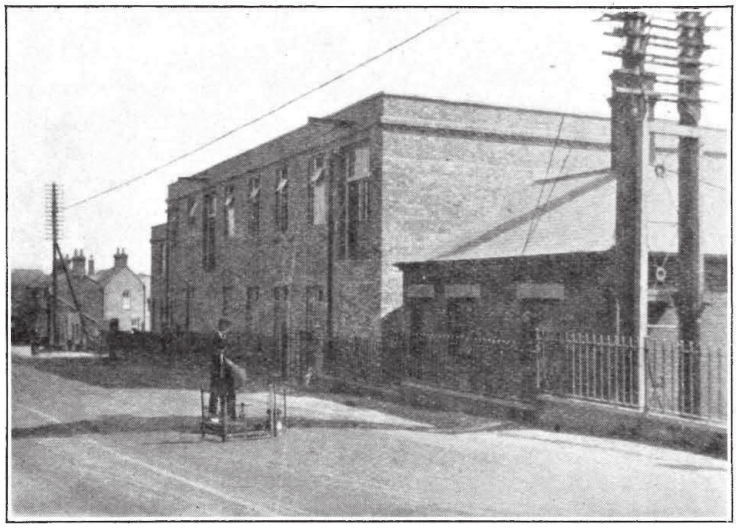


Fig. 1.—Fenny Stratford Repeater Station.

When the London—Manchester Cable was laid, in 1921, a temporary Repeater Station, equipped with 40 22-type repeaters, was installed in the Test Hut and a temporary hut erected to house the Power Plant, consisting of a 10 H.P. oil engine and the necessary batteries for the filament plate and grid circuits. This plant was in use up to the time of the transfer of the Manchester Cable into the new Repeater Station in June, 1925. The temporary Repeater Plant is being transferred to Manchester and the Power Plant has been transferred to Marks Tey Repeater Station.

The new Repeater Station is situated where the main Watling street crosses the Grand Junction Canal and is adjacent to the "Old Main Line Test Hut." Those officers of the department

who served with the Royal Engineers doubtless remember the place well.

Fig. 1 shows side view on Watling Street.

The distance from London is 46 miles and from Derby 82 miles. The building is of brick with reinforced concrete floors. The roof is flat, being so designed for the extension of the building upwards. It is at present a two-storey building and the layout is as follows:—

Basement.—A cable chamber where the Trunk cables enter the building; Heating Installation chamber.

Ground Floor. Power Room, Battery Room, Linemen's Room, and Lavatories.

First Floor. Repeater Room, Inspectors' Office and Linemen's Room.

The building was designed to accommodate 1000 repeaters (ultimately).

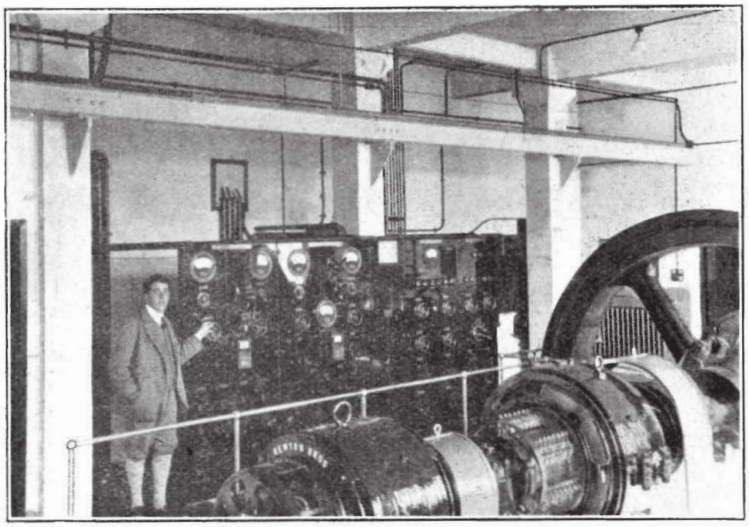


FIG. 2.—FENNY STRATFORD POWER BOARD.

Power Plant (*Engine Room*).—The plant consists of the following:—

2 80 BHP semi-diesel engines.
2 32 Kilowatt Machines (for charging filament A batteries).
2 11 Kilowatt Machines (for charging plate B Batteries).
2 Ringing Dynamotors for 17 cycle ringing circuits.
2 Electric Motors, 5 H.P., for driving compressors.
2 Electric Motors, 2½ H.P., for driving fuel pumps.
2 Electric Motors, 2 H.P., for driving cooler pumps and fans.
2 Heenan Water Cooling Plant for Engines.
2 Air compressor pumps for charging containers.

1 Power Switch Board of 4 panels, equipped with the necessary switches, circuit breakers, and testing instruments.

1 Travelling Crane for lifting weights up to 25 cwt.

Fig. **2** shows the Power Switchboard.

The engines are direct-coupled; one 32 Kilowatt Generator, 32 volts at 1,000 amps., for charging A Batteries, and one 11 Kilowatt Generator, 200 volts at 50 amps., for charging B Batteries. The air compressors, motors, and cylinders are used for starting the engines. A safety device, the Moniton Valve, is associated with the water cooling system. The fuel used is crude

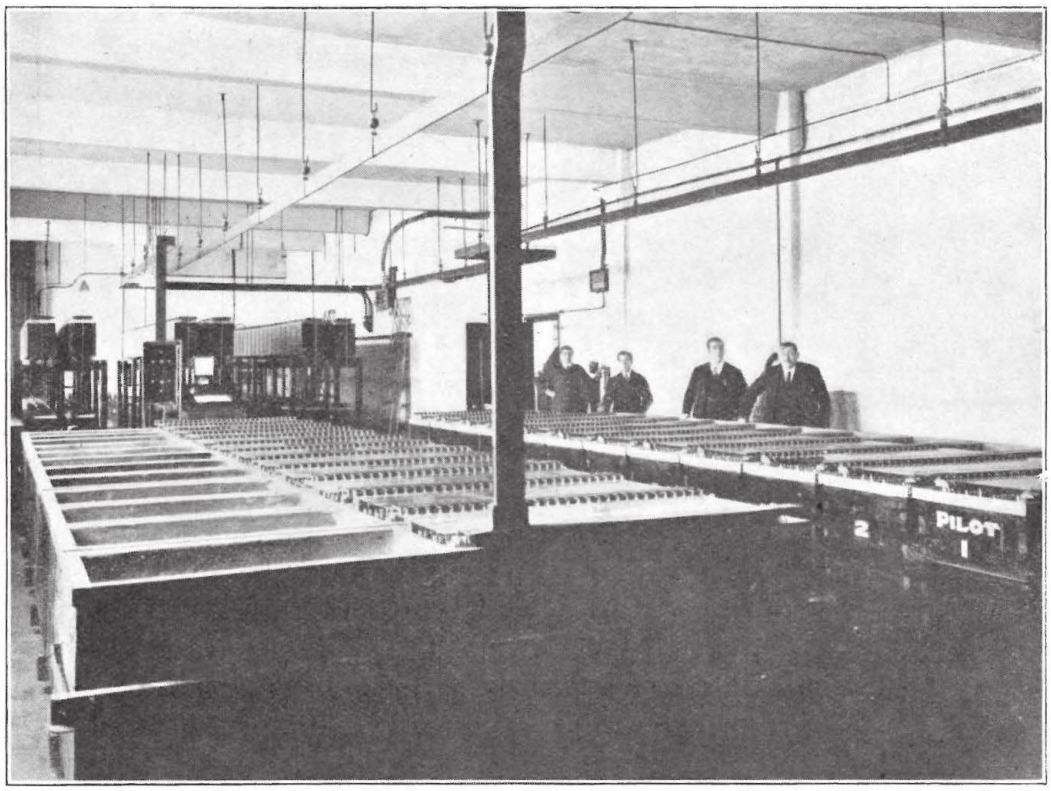


FIG. 3.—FENNY STRATFORD BATTERY ROOM.

oil of a specific gravity .93. The oil is stored in two 2,500 gallon tanks situated under the front entrance. The oil is conveyed to the subsidiary tanks by electrically driven rotary pumps. A few details with respect to the Engines and Power Plant may be of interest.

Weight of flywheel = 6 tons 14 cwt.
Height ,, = 9 ft. 2 ins.
Width ,, = 1 ft. 4 ins.
Cost of fuel per unit generated = ½d.
Makers: Messrs. Ruston and Hornsby, Lincoln.

Machine and Power Cables were supplied and installed by Messrs. Newton Bros., Derby, both firms being sub-contractors to Messrs. The Automatic Telephone Coy., Liverpool, who were the main power plant contractors.

Power Plant (Battery Room. Fig. **3**).—The Batteries were installed by the makers, the Alton Battery Coy., Alton, Hants, who were sub-contractors to The Automatic Telephone Coy., and consist of the following:—

2 ("A") Filament Batteries, 24 volts of 5,075 amp. hr. capacity, with an ultimate capacity of 9,450 amp. hr These capacities are calculated at the 10 hr. rate.

Weight of 1 Cell = 2 tons 4 cwt.
Total weight of "A" Batteries = 52 tons 16 cwt.

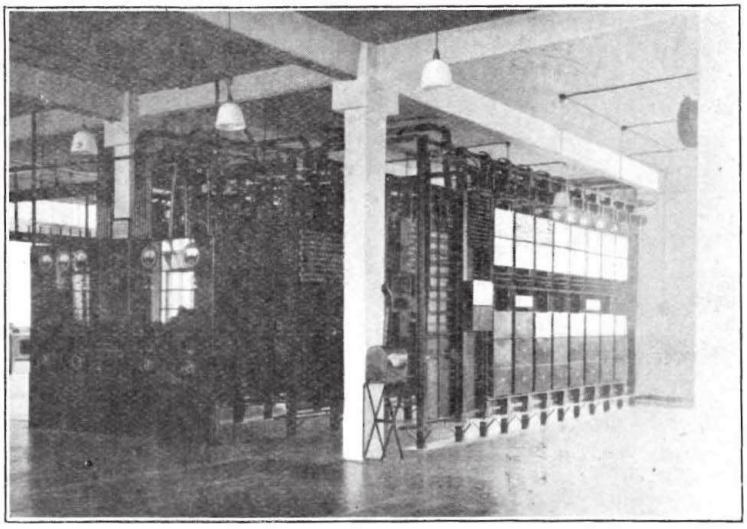


FIG. **4**.—FENNY STRATFORD 2-WIRE REPEATER RACKS.

"B" Plate Batteries. There are 3 sets of 75 cells, *i.e.*, 150 volts of 300 amp. hr. capacity, and are utilised as follows:—

1 set on Plate circuits of Repeaters.
1 ,, ,, Electric Light circuits (123) and Auxiliary Motors.
1 ,, ,, Charge, or in reserve.
5 Regulating Cells for use in Electric Light circuits.

"C" Grid Batteries. 2 sets of 5 cells, each 10 volt 20 amp. hr. capacity for priming the Grid circuits.

"D" Counter E.M.F. 2 sets of 10 cells, each 20 volt for opposing the "B" battery to give a terminal voltage of 130 volts for the plate circuit.

Total number of cells in Battery Room = 284.

Peak load "A" Battery = 100 amps.
,, ,, "B" ,, = 2.5 ,,

Repeater Room.—The cables serving the building are the TSX.MR cable 160/40 and the TSX.DY cable 88/40 and 156/20.

All cables pass to the Repeater Room from the cable chamber *via* the cable chute and are terminated on Tablets, TK Test, 18 circuit.

A Cable Test Desk equipped with a precision test set is provided for dealing with incipient faults.

From the line transformers the circuits are cabled to the Cable Distribution Frame, where they are cross-connected to the Repeater Units.

Fig. 4 shows a general view of the 2-wire Repeater Racks, with the Voltage Control Boards in the foreground. Two additional racks have been installed since this photograph was taken.

Four-wire repeater units have been installed by the G.E.C. This equipment is of a temporary nature and is known as the Fire Emergency Equipment. On the completion of the 4-wire equipment now being installed by the Standard Telephones and Cables Ltd., the temporary 4-wire equipment will be recovered, and stored for use in emergency.

The station at the time of writing has 146 Repeaters working, and is equipped with the following :—

268	2-wire repeaters	= 536	valves
54	4 ,, ,,	= 216	,,
13	4 ,, ,,	= 53	,,
	Total ...	804	,,

A Repeater Test Desk equipped with an impedance bridge, gain set, and equipment for connecting lines to other stations and Repeater Racks, will be installed shortly. The whole of the Repeater and associated apparatus was installed by the Standard Telephones and Cables Ltd. with the exception of the temporary 4-wire equipment.

NORTHERN CENTRE.

The Session opened on the 20th October, when the Vice-Chairman of the Centre, Mr. F. G. C. Baldwin, M.I.E.E., introduced a paper on " Scientific Organisation and the P.O. Engineering Department," which was taken as read in order to afford sufficient time for discussion. The paper dealt in a general way with scientific management in relation to the work of the Department and of the individual worker and gave illustrations of the application of scientific organisation with satisfactory results to certain aspects of the work in the Northern District, *e.g.*, Repairing of Telephone Switchboard Cords, The Handling of Stores,

etc. Composite Works and their organisation, and the relationship of Planning to the Execution of Works were also subjects of detailed consideration, and the paper concluded with the suggestion that the subject of scientific organisation should be " included in the curricula of all our educational establishments as an essential companion to the pure and applied sciences and provided for in the syllabus of our examining bodies," the author's opinion being that " the planning of works in a scientific manner, the preparation and use of comprehensive works instructions, the organisation of works and the exercise of scientific methods generally as labour saving and economic measures can all be developed to a much higher state of perfection with very important advantages to the Engineer and the Department generally."

The second meeting of the Session was the occasion when Mr. J. Lane's paper on " The Control of Advice Note Work " was the subject of consideration and discussion, the paper being accepted as read. The paper covered the specified ground in a very complete and adequate manner and will be a valuable " vade mecum " to all members interested in this phase of the Department's work. In the opening paragraphs of the paper Mr. Lane stated that " the provision of additional telephone facilities is second in importance only to the maintenance of the service to existing subscribers and in the same way as everyone realizes the necessity for, and takes a pride in, restoring the service without delay in the case of breakdowns, so special efforts should be made to complete quickly orders received for new subscribers. Further, the staff comes into immediate contact with the public and the credit of the Department is closely associated with the speedy execution of this class of work, and in addition it is highly desirable that non-revenue earning plant should be brought into operation as quickly as possible. The Secretary to the Post Office very strongly supports the view that nothing more seriously tends to discredit the administration of the telephones than delay in providing service, and the object of this paper is to illustrate and facilitate the control of Advice Note work."

The members of the Centre have been invited by the Institution of Electrical Engineers to attend the Faraday Lecture by Professor Thornton, O.B.E., D.Sc., M.I.E.E., on the 24th November, the subject being " What is Electricity? "

West Hartlepool Exchange Transfer.

On the 25th September last another link with the past was severed when the subscribers at West Hartlepool were transferred from the old Magneto Exchange to the new Siemens' No. 16

Automatic Exchange. The subscribers at Hartlepool were transferred at the same time—Hartlepool being a satellite Exchange.

The installed capacity of the new Main Exchange is :—

	Ordinary Subs.	*Coin Box Lines.*
Initial Equipment ...	1100	30
Ultimate ,, ...	1700	50

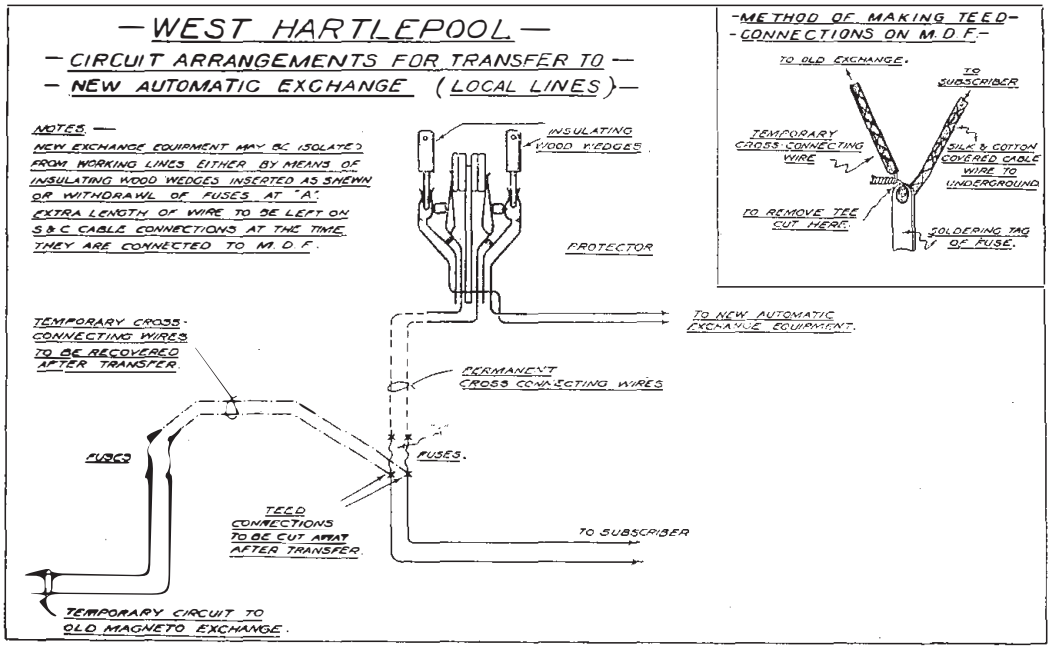
with M.D.F. equipment for 3,080 lines.

The capacity of the Satellite Exchange at Hartlepool is :—

	Ordinary Subs.	*Coin Box Lines.*
Initial Equipment ...	170	10
Ultimate ,, ...	200	10

with M.D.F. equipment for 480 lines.

The Main Exchange is accommodated in a substantial building purchased by the Department and adapted by the Office of Works for the purpose. It is situated about 400 yards from the old Exchange.


—WEST HARTLEPOOL—
—CIRCUIT ARRANGEMENTS FOR TRANSFER TO—
—NEW AUTOMATIC EXCHANGE (LOCAL LINES)—
NOTES.—
NEW EXCHANGE EQUIPMENT MAY BE ISOLATED FROM WORKING LINES EITHER BY MEANS OF INSULATING WOOD WEDGES INSERTED AS SHEWN OR WITHDRAWL OF FUSES AT "A".
EXTRA LENGTH OF WIRE TO BE LEFT ON S & C CABLE CONNECTIONS AT THE TIME THEY ARE CONNECTED TO M.D.F.
INSULATING WOOD WEDGES
PROTECTOR
TO NEW AUTOMATIC EXCHANGE EQUIPMENT.
TEMPORARY CROSS-CONNECTING WIRES TO BE RECOVERED AFTER TRANSFER.
PERMANENT CROSS CONNECTING WIRES
FUSES
FUSES.
TEED CONNECTIONS TO BE CUT APART AFTER TRANSFER.
TO SUBSCRIBER
TEMPORARY CIRCUIT TO OLD MAGNETO EXCHANGE.
-METHOD OF MAKING TEED-
-CONNECTIONS ON M.D.F.-
TO OLD EXCHANGE.
TO SUBSCRIBER
TEMPORARY CROSS CONNECTING WIRE
SILK & COTTON COVERED CABLE WIRE TO UNDERGROUND
TO REMOVE TEE CUT HERE.
SOLDERING TAG OF FUSE.

Owing to the situation of the Exchange with respect to the cabling and also due to a development scheme being carried out at the same time as the transfer arrangements, it was found possible, by utilising the spare wires, to loop all the working circuits through the new Exchange M.D.F. and back to the old Exchange. The arrangements made were such that there were no external tees either underground or open. In all cases the tees

were made on the new Exchange M.D.F. in the manner shown on the accompanying diagram.

When the external cables were terminated on the new Exchange M.D.F. a ¾ inch extension was left on every S. & C.C. wire end. To these extensions the temporary jumpers carrying the circuits back to the old Exchange were soldered as shown in inset on diagram. The temporary jumpers were not passed through the jumper rings, but were tied together outside the rings. This was in order to avoid interference with the permanent jumpers and to facilitate speedy removal after the transfer. After all the jumpering had been completed the S. and C.C. wire extensions not required for cross-connecting were cut away.

Except for testing purposes the fuses were not inserted at "A" until the day previous to the transfer, prior to which the new exchange equipment had been insulated by means of sash line inserted between the Test Springs of the Protectors.

Special telephone circuits were provided from the Auto Exchange to the principal points affected by the transfer, and in these cases a loop was made in the sash line so as not to insulate the Test Springs of the Protectors concerned.

At the old Exchange the usual arrangements were made for transfer by withdrawing the Heat Coils, prepared linen tape 7/8″ wide folded to 7/16″ being inserted behind the Heat Coils on both sides of each 50 line strip, the tape being looped at the bottom.

At Hartlepool Exchange the new Automatic Exchange was installed in the same building at the Magneto Exchange, and in this case the Auto Equipment was terminated on duplicate protector apparatus on the M.D.F. The method of transfer was first to insert wedge-shaped hardwood strips in the line springs of the protectors serving the old Exchange Equipment and then to withdraw the sash cord from the line springs of the protectors serving the new equipment.

Half the trunks and junctions were transferred in advance at 1.0 p.m. To enable this to be done, instead of sash cords, wood wedges were used for insulating the Test Springs of the Protectors, those in the Junctions transferred in advance being withdrawn separately. The remainder of the wood wedges in the Junction circuits were threaded with whip-cord and were dealt with at the same time as the Main transfer.

At 2.0 p.m. the signal was given for the transfer to be carried out; the Heat Coils were withdrawn at the Old Exchange, after which the wood wedges and sash cords were withdrawn at the New Exchange—the transfer at Hartlepool proceeding simultaneously. The whole period occupied by the transfer was only 35 seconds, after which the Traffic Staff immediately commenced to test out.

The actual number of working lines transferred was:—

Direct Exchange Lines ...	1111
Junction Lines	12
Trunk Lines	61
	1184

The number of faults after the transfer being:—

Line	3
Exchange	5
Subs. Apparatus	3
	11

or approximately 1%.

After the testing out had been completed, the whole of the tees were cut away and the temporary jumpers removed from the M.D.F., this work being completed before 9.0 p.m.

In order to avoid interference from the subscribers' magneto apparatus the work of cutting away the old apparatus and completing the permanent connections on the auto apparatus was immediately commenced, and this work was completed by the end of the following week, the apparatus being afterwards collected by motor van.

It should perhaps be mentioned that although it was necessary after the transfer to open joints at certain points in order to restore spares to their respective D.P.'s the work carried out was on spare wires only and there was no interference with any working circuit.

J.J.S.

SOUTH LANCS. CENTRE.

The Session was opened on the 18th October with an address by the Chairman, Mr. W. J. Medlyn, outlining the "Progress and Development in the Post Office Engineering Department" during the preceding year. The annual resumé of the Department's activities is highly appreciated by the membership and on this occasion the address surpassed in interest those of previous years.

The lecturer for the second meeting of the Session held on November 15th was Mr. A. Magnall, until recently Sectional Engineer of the Manchester West Section. The subject selected by the lecturer was his "Reminiscences." A brief review of his career was given which proved both interesting and instructive. He described how starting on the lower rung of the ladder he had climbed to the position of Sectional Engineer and ascribed his success mainly to hard work. Many problems with which he had

been contronted over his long experience, as telephone engineering practice developed, were described and were illustrated by a number of lantern slides. Some instances in which, in pursuance of his duties, he had found himself in difficult and dangerous positions, were related, and the manner in which he extricated himself bore witness to his capacity, well known to his colleagues, for overcoming difficulties which to many would have appeared insurmountable. The lecture was interspersed with a lively humour and the reminiscences of one who by sheer hard work and determination has made good, should prove an inspiration to the younger members of the Institution.

A pleasing feature of the occasion was the presence of colleagues with whom the lecturer had been associated in the earlier stages of his engineering career. Among these was Mr. J. M. Shackleton, who proposed the vote of thanks, and Messrs. J. Nevin and J. Parker, who preceded Mr. Magnall in retiring from the strenuous life of the Post Office Engineering Department for, it is hoped, a long period of leisure. A separate article dealing with Mr. Magnall's retirement will be found below.

Mr. Alfred Magnall.

The 17th October, 1926, marked the retirement from the service of Mr. Magnall, Sectional Engineer, Manchester West Section. It is with very genuine regret that we record the official passing of our old friend, for his sterling qualities of heart and mind had endeared him to everyone.

Mr. Magnall's service extends over 43 years, commencing with the Lancashire and Cheshire Telephone Co., which he joined in Liverpool in 1883. He rose rapidly from Lineman to Inspector and then to District Manager, Warrington. But in this last capacity his engineering abilities were somewhat wasted and he was very soon promoted to be Engineer at Manchester with a large and doubtless welcome addition to his salary. He entered on his new duties with an enthusiasm which never waned. He was always generous in giving the results of his vast experience to his colleagues and he has many lectures and papers to his credit. It would, moreover, be fair to describe Mr. Magnall as one of the pioneers in the development of modern external plant.

In 1911 Mr. Magnall was responsible for the lay-out of the new telephone system in Constantinople, and it must be a source of pride to him to know that his forecasts have been fully justified in the years which have elapsed.

With the transfer of the local telephone systems to the State, Mr. Magnall became a civil servant and very soon earned the affectionate regard of everyone. If reason for this be demanded,

then it is to be found in a vivid personality allied with transparent honesty in all his dealings and directed by a kindly heart.

Owing to the uncertainty of Mr. Magnall's future plans the presentation, made to him on the 18th October, had, perforce, to take the form of a well lined case of Treasury Notes. The meeting was presided over by Mr. Medlyn and the presentation made by Mr. T. E. Herbert, who claimed Mr. Magnall as a friend of 30 years' standing.

T.E.H.

Mr. Alfred Magnall.

NORTH WESTERN CENTRE.

The opening meeting of the 1926-27 Session was held in the Lecture Hall of the Preston Scientific Society, Preston, on the 11th October, 1926, when a paper entitled " A Comparison of Desiccation Methods " was read by Mr. E. Hopper.

Mr. Shackleton presided, and in his opening remarks referred to the interesting programme arranged for the Winter Session.

Mr. Hopper opened his paper with an explanation of the physical considerations involved in the process of desiccation and proceeded to explain the application of Dalton's, Boyle's and Charles' laws. The questions of pressure and temperature were dealt with at length, the advantages of the use of Carbonic Acid Gas, Compressed Air, etc., compared, and the treatment of isolated joints touched upon. The paper was illustrated by special apparatus and diagrams and was followed by a useful discussion.

The second meeting of the 1926-27 Session was held in the Lecture Hall of the Preston Scientific Society on the 2nd November, 1926, when a good attendance of members assembled to hear a paper entitled "Local Line Plant Economics" by Mr. H. Kitchen, of the Engineer-in-Chief's Office. Mr. Shackleton presided, and before the proceedings commenced the members present stood in silence as a mark of respect for Captain A. W. Sirett (Executive Engineer, Preston External Section), who had passed away since the last meeting of the Centre.

The Chairman explained that owing to unavoidable circumstances it was not possible for Mr. Kitchen to attend in person to read his paper, but that Mr. W. B. Crompton, of the Local Lines Section at Headquarters, had kindly consented to come to Preston and read the paper in Mr. Kitchen's stead.

The paper opened with a reference to the subject of expenditure on local line plant, and statistics illustrating the financial position of the service were presented. The general question of economics was then dealt with and the following items were covered:—Ducts, Wood Troughing, Boring Apparatus, Contract Work, Teeing Systems, Records, Types of Cables, Overhead Work, Lay-out of areas, Junction & Line Plant, Transmission, etc. The paper was illustrated by lantern slides.

A hearty vote of thanks was accorded to Mr. Kitchen for his interesting and informative contribution and to Mr. Crompton for his kindness in reading the paper and for his lucid exposition of the various details. A number of points were raised in the discussion to which Mr. Crompton replied at length.

A meeting of the Centre was held at Preston on the 6th December, 1926, when a paper entitled "Ways and Means in an Engineering Section" was read by Mr. S. Upton, A.M.I.E.E.

Mr. Shackleton presided over a good attendance.

Mr. Upton opened his paper with a review of the scope of the subject and proceeded to deal with the following points:—Staff, Works, Faults, Correspondence, General Office Work, Recruitment and Training. The paper was illustrated by specially prepared diagrams.

Upon the proposition of Mr. W. J. Finlayson, seconded by Captain Buchanan, and supported by other speakers, a hearty

vote of thanks was conveyed to Mr. Upton for his interesting paper. An animated discussion followed and many points were raised to which Mr. Upton replied.

D. BARRATT.

CAPTAIN ALBERT WILLIAM SIRETT, R.E. (T.), A.M.I.E.E.

The friends throughout the service of Captain A. W. Sirett will regret to hear of his premature death at his home in Fulwood, Preston, on the 23rd October. Captain Sirett, who was in his fifty-seventh year, entered the Post Office service on the 1st April, 1885, as a telegraphist at Manchester, where his father was Superintendent of Telegraphs. In September, 1891, he was transferred to the Engineering Department as a 2nd Class Junior Clerk, and after service in that capacity and as 1st Junior Clerk, first at Manchester under the late Mr. John Doherty, and afterwards at Cork and Newcastle, he was appointed 2nd Class Engineer on the 1st May, 1897, with headquarters at Coventry. On promotion to a 1st Class Engineership Captain Sirett removed to the South Wales District in April, 1906, and was stationed at Gloucester as Sectional Engineer, where in due course he passed to the new class of Executive Engineer on the 1st July, 1911.

Captain Sirett was a keen Volunteer and Territorial soldier, having served successively in the 5th (Ardwick) V.B. Manchester Regiment, Newcastle-upon-Tyne Royal Engineers, 2nd V.B. Warwickshire Regiment and 5th V.B. Gloucestershire Regiment. He joined the first-named Corps, with which the whole of the male members of his family had been associated since its formation in 1859, in 1888 and rapidly rose to the rank of Sergeant. His removal to Newcastle entailed severance from that Corps, but he immediately joined the Newcastle Engineers and was promoted to Sergeant within a month of attestation, after having passed through the qualifying examination in Military Engineering, a testimony to his interest and thoroughness in the Volunteer movement. During his service with the Warwickshire Regiment he rose to the rank of Colour Sergeant and became one of the leading shooting men of the County of Warwickshire. He was the "best shot" of his battalion, and was chosen to go to Bisley to represent it in the National Competitions and was elected a member of the English Twenty Club, a high honour amongst shooting men. He finished his Territorial peace time service in the Gloucestershire Regiment in December, 1911, with the rank of Quartermaster and Honorary Lieutenant, having received the Volunteer Long Service Medal and the Coronation Medal (King George V.).

On the outbreak of the Great War, Captain Sirett immediately

volunteered for service and on 1st July, 1915, he was gazetted 2nd Lieutenant in the Royal Engineers Signal Service, the same Gazette announcing his promotion to Lieutenant. He was posted to the Divisional Signal Company of the 2/1 Welsh Division, joining the Division in North Wales after a short course of training and was there appointed Acting Captain. Early in 1916 he was sent to Farnham to raise and train the 71st Divisional Signal Company. He took this Company through the whole course of their training, proceeding with them to Colchester and Haynes Park and received gratifying reports from his superior officers upon the methods and success of his work. Towards the end of 1916 he was ordered to France, where he joined the Headquarters of the famous Anzac Corps and remained on the lines of communication until the Armistice. During this period he was second in command of "L" Company, Royal Engineers Signal Service, at G.H.Q.

Captain Sirett was demobilized on the 26th January, 1919, and on resuming his civil duties was transferred to the North Western District in charge of the Preston Section and there he remained until after only a fortnight's illness he succumbed to an attack of pneumonia.

Captain Sirett was interred with military honours in the quiet churchyard at Broughton, near Preston, on the 27th October, when a representative gathering of his late colleagues and friends attended to pay their last respects to his memory. A party from the East Lancs. Regiment, accompanied by his friend Lieut.-Col. Cranston, O/C Fulwood Depot, fired three volleys over the grave, followed by the sounding of the "Last Post" and the "Reveille."

In addition to his military activities already noticed, Captain Sirett was greatly interested in all forms of sport and particularly in Rugby football. He was treasurer of the Preston Grasshoppers R.F.C. and County representative, and a member of the West End Tennis Club and of the Broughton and District Social Club. He also took a prominent part locally in all movements for helping ex-service men and was treasurer of the Preston United ex-Service Men's Committee (War Widows and Orphans). R.I.P.

R.A.J.

SCOTLAND WEST CENTRE.

The first meeting of the current Session was held in the Royal Technical College on Monday, 4th October. In the unavoidable absence of Mr. Aitken the chair was taken by Mr. Hardie. The lecturer for the day was Mr. Vincent A. M. Bulow, of the British Broadcasting Coy., and the subject treated was "Some Links in the Broadcasting Chain."

The links considered were :—

Studio. General requirements; Resonance and damping; Methods adopted to improve the natural acoustics; Artificial echo.

Microphones. Discussion of various types of pick-up device used by B.B.C.

Amplifiers. General description of the various amplifiers used, including Line Correctors, and giving the average figures for gain or loss in the various pieces of apparatus.

Transmitters. Brief description of the transmitting apparatus at Main and Relay Stations.

Receivers. Brief statement of requirements.

The lecture was fully illustrated by lantern slides. On conclusion a hearty vote of thanks was accorded to the lecturer.

NORTH WALES CENTRE.

The first meeting of the 1926-27 Session was held at Shrewsbury on 13th October, 1926, when to an audience of about 75 members Mr. G. H. Carrier read a paper entitled "The Control of Expenditure by Supervising Officers." Mr. Carrier after outlining responsibilities of supervising officers in the matter of control went on to describe the headings under which funds are estimated and allocated, and to detail the methods of keeping records of allocations commitments and expenditure under the various classes of work. Finally the methods of record by the Inspector and the following up of progress were gone into very fully, and slides of the various printed forms used in these directions were shown on the screen.

The second meeting was held at Birmingham on 11th November, when a visit was paid to the Birmingham Telephone Repeater Station. There was an attendance of 97 members who were made up into conveniently sized groups as they arrived at the entrance, and taken on a tour of inspection by members of the repeater station, and of the Power Section Staffs, who explained clearly the functions of every piece of apparatus. The arrangements were so carefully made, that each member had an opportunity of seeing and understanding every unit in the whole installation, and general appreciation of the arrangements was expressed as the various groups completed their visit. Later on the same afternoon a meeting was held at the Birmingham Technical Schools, when Mr. R. P. Collins read a copiously illustrated paper entitled the "Birmingham Telephone Repeater Station." The arrangements of two and four valve repeaters

were fully explained, and the whole lay-out of the Birmingham Station described. The lecturer described also in a very interesting fashion the maintenance testing and staffing arrangements which had been made at Birmingham.

The third meeting was held at Shrewsbury on 8th December, 1926, when J. B. Salmon read a paper on "Ferro Concrete Construction" to an audience of 75. After referring briefly to the general characteristics of concrete, the lecturer went on to the great extension in the use of concrete in building construction, and its utility in Departmental work.

Mr. Salmon, not satisfied with searching out and marshalling an imposing array of facts and figures not available to the ordinary member, had visited the Ship Canal Portland Cement Manufacturers works at Ellesmere Port, and had secured a large number of photographs of the processes of manufacture which were projected in illustration of his lecture.

Mr. Salmon exhibited also a number of specimens of the various constituents of Portland Cement, and of samples prepared for compression and tensile tests and after the lecture had terminated the members adjourned to an adjoining laboratory where a tensile testing machine was exhibited, and several samples were tested to destruction.

BOOK REVIEWS.

"Practical Physics." By T. G. Bedford, M.A., F.Inst.P. Longmans, Green & Co., Ltd. 10/6 net.

The volume is based upon the experimental work carried out by junior students at the Cavendish Laboratory, Cambridge University, but these experiments have been supplemented by accounts of other work not actually covered by the course conducted by the author.

The matter is divided into five parts: (1) Mechanics and Properties of Matter; (2) Heat; (3) Light; (4) Sound, and (5) Magnetism and Electricity. One hundred and fifty experiments are described, and in most cases the object of the experiment is explained and the precautions necessary for accuracy elaborated.

As the author admits, the book is intended to supplement and not to replace oral instruction, but it will form a valuable reference for others than students and teachers. Lecturers and demonstrators of physical sciences will find it very useful.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Murray, J. K. ...	Executive Engineer, Scot. E. District.	District Manager, Scotland W. Telephone District.	29-9-26
Warner, A.	Assistant Engineer London District	Executive Engineer, London District.	11-10-26
Hammond, G. W. ...	Assistant Engineer N. East District	Executive Engineer, London District.	17-10-26
Bell, J. H.	Assistant Engineer London District	Executive Engineer, London District.	11-10-26
Stewart, W.	Assistant Engineer Scot. W. District.	Executive Engineer, Scot. East District.	31-10-26
Fletcher, Capt. J. E....	Assistant Engineer N. East District.	Executive Engineer, S. Lancs. District.	24-10-26
Dunlop, A.	Second Engineer, H.M.T.S. Monarch.	Chief Engineer, H.M.T.S. Monarch.	26-9-26
Middleton, W.	Third Engineer, H.M.T.S. Monarch.	Second Engineer, H.M.T.S. Monarch.	26-9-26
Thomson, A. J. ...	Fourth Engineer, H.M.T.S. Alert.	Third Engineer, H.M.T.S. Monarch.	7-11-26
Paines, A. V.	Fourth Officer, H.M.T.S. Monarch.	Third Officer, H.M.T.S. Alert.	7-11-26
Beer, H. G.	Prob. Asst. Engineer.	Assistant Engineer.	1-9-26
Britton, F. T. ...	,,	,,	,,
Moffatt, C. E.	,,	,,	,,
Ryall, L. E.	,,	,,	,,
Semple, L. G. ...	,,	,,	,,
Manning, F. E. A. ...	,,	,,	,,
Bryden, J. E. Z. ...	,,	,,	,,
Brent, W. H.	,,	,,	,,
Gemmell, W. T. ...	,,	,,	,,
Davies, T. A.	,,	,,	,,
Bewick, W.	,,	,,	,,
Barker, P. L.	,,	,,	,,
Loftus, R. W. ...	Chief Inspector, London District.	Assistant Engineer. London District.	24-11-26
Graham, R. B. ...	Chief Inspector, S. Lancs. District.	Assistant Engineer. N. East District.	To be fixed later.
Barlow, T. F.	Chief Inspector, N. East District.	Assistant Engineer. N. East District.	24-11-26
Graham, C.	Chief Inspector, S. East District.	Assistant Engineer. S. East District.	To be fixed later.
Keeble, A. G.	Chief Inspector, Testing Branch.	Assistant Engineer. Testing Branch.	24-11-26
Hooper, W. N ...	Skilled Workman, Class I., S. West District.	Inspector, S. West District.	8-1-26
Colbourne, R. W. ...	,,	,,	1-3-26
Davey, W. H. ...	,,	,,	6-4-26
Ferris, J. T.	,,	,,	10-1-26
Evans, R. B.	,,	,,	1-3-26
Morgan, C. R. ...	,,	,,	1-3-26
Harris, A. E.	,,	,,	1-3-26
Moss, J.	,,	,,	6-11-25
Shaw, J.	,,	,,	29-4-26
Woodley, E. T. M. ...	,,	,,	1-3-26
Coles, F. S.	,,	,,	1-3-26
Woods, D. T.	,,	,,	20-9-26
Swan, R. J.	Skilled Workman, Class I., Eastern District.	Inspector, Eastern District.	19-5-26

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date
Mentasti, R. G. B. ...	Skilled Workman, Class I., S. Lancs. District.	Inspector, S. Lancs. District.	1-7-26
McNamara, H. J. ..	Skilled Workman, Class I., Scot. West District.	Inspector, Scot. West District.	11-1-26
Chubb, E.	Skilled Workman, Class I., E.-in-C.O.	Inspector, E.-in-C.O.	24-8-25
McFarlane, A. E. ...	Skilled Workman, Class I., E.-in-C.O.	Inspector, E.-in-C.O.	5-6-26
Rule, C.	Skilled Workman, Class I., Met. Power District.	Inspector, Met. Power District.	8-3-25
Grigg, G.	Skilled Workman, Class I. S.Mid. District.	Inspector, S. Mid. District.	11-5-25
Webster, C. J. ...	Skilled Workman, Class I. S. Mid. District.	Inspector, S. Mid. District.	13-11-26
Reardon, J.	Telegraphist, C.T.O.	Repeater Officer, Class II., S. West District.	7-3-26
Topham, C. L. ...	S.C. & T., Leeds.	Repeater Officer, Class II., N. Wales District.	29-8-26

RETIREMENTS.

Name.	Grade	District.	Date.
Shorrocks, F. W. ...	Asst. Staff Engineer.	E.-in-C.O.	19-10-26
Magnall, A.	Executive Engineer.	S. Lancs.	17-10-26
Beasley, B. J. ...	Executive Engineer.	E.-in-C.O.	21-10-26
Hill, G. J. W. ...	Assistant Engineer.	Testing Branch.	27-10-26
Nevin, J. A.	Assistant Engineer.	S. Lancs.	9-10-26
Thorogood, S. W. ...	Chief Inspector.	S. Wales.	18-8-26
Pulford, A. R. ...	Chief Inspector.	N. Ireland.	14-11-26
Saville, D. B. S. ...	Chief Engineer	H.M.T.S. Monarch.	25-9-26
McNeil, A.	Inspector.	N. Western.	1-9-26

DEATHS.

Name.	Grade.	District.	Date.
Sirett, A. W.	Executive Engineer.	N. Western.	23-10-26

TRANSFERS.

Name.	Grade.	Transferred.		Date.
		From.	To.	
Holland, A. E. ...	4th Officer.	"Alert"	"Monarch"	7-11-26
Day, W.	Assistant Engineer.	E.-in-C.O.	London District.	1-12-26

STAFF CHANGES.

CLERICAL ESTABLISHMENT.

PROMOTIONS.

Name.	Grade.	District.	Date.
Medland, G. F. ...	Executive Officer. E.-in-C.O.	Staff Officer. E.-in-C.O.	12-8-26
Malkin, J. L.	,,	,,	12-8-26
Oldfield, G.	,,	Acting Staff Officer, E.-in-C.O.	12-8-26
Stephenson, W. H. ...	,,	,,	12-8-26
Taylor, A. J.	Clerical Officer, S. Wales District.	Higher Clerical Officer, S. Wales District.	3-10-26
Turner, F. W. ...	Clerical Officer, N. Wales District.	Higher Clerical Officer, Scot. West District.	To be fixed later.
Williams, J. T. ...	Clerical Officer, S. East District.	Higher Clerical Officer, N. East District.	do.
Penfold, F.	Clerical Officer, S. East District.	Higher Clerical Officer, Scot. West Dictrict.	do.
Goode, W.	Clerical Officer, E.-in-C.O.	Executive Officer, E.-in-C.O.	12-8-26

TRANSFERS.

Name.	Grade.	From.	To	Date
Coleman, A. T. ...	Higher Clerical Officer.	South Wales.	South West.	3-10-26

RETIREMENTS, ETC.

Name.	Grade.	District.	Date.	Remarks
Eaton, J. C. ...	Higher Clerical Officer.	South Mid.	14-11-26	Retired.
Thorne, A. E. ...	Executive Officer.	E.-in-C.O.	10-11-26	Deceased.
Lilburn, G. L. ...	do.	do.	3-10-26	do.

BOARD OF EDITORS.

B. O. ANSON, M.I.E.E., Chairman.

E. H. SHAUGHNESSY, O.B.E., M.I.E.E., M.I.R.E.
Lieut.-Col. A. C. BOOTH, M.I.E.E
J. W. ATKINSON, M.I.E.E.
H. LONGLEY.

W. CRUICKSHANK, M.I.E.E., Managing Editor.
J. J. MCKICHAN, Assistant Editor, A.M.I.E.E.

COMMUNICATIONS.

All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, Alder House, London, E.C.1.

Binding covers and copies of the Contents for Vol. 3 to 18 are available, and may be obtained from the local agents for 1*s*. 6*d*. and 3*d*. respectively. Subscribers can have their copies of Vol. 18 bound, with index included, at a cost of 3*s*. by sending the JOURNALS to the local agents. Orders should indicate whether the original binding with black lettering, or the later pattern in gold, is required.

The price of the JOURNAL is 1*s*. 6*d*. (1*s*. 9*d*. post free) per copy, or 7*s*. per annum, post free. All back numbers 2*s*. each.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

Officers of Colonial and Foreign Telegraph Administrations who are engaged in Electrical Engineering Works may be admitted as Colonial and Foreign Corresponding Members respectively, after application.

Subscription payable annually in advance on 1st April in each year:

Colonial Members	... ...	£1 0 0
Foreign ,,	... ...	£1 10 0

These sums include Annual Subscription to the Journal of P.O. Electrical Engineers and the supply of all Professional Papers issued during the period covered by subscription.

Forms of application for Colonial and Foreign Membership can be obtained on application to

The Secretary,
Institution of P.O.E. Engineers,
G.P.O., Alder House, E.C.1.

BOOTH-BAUDOT AWARD.

The Council wishes to call attention to the "Booth-Baudot Award" of £5 which is now offered annually for the best improvement in TELEGRAPH, TELEPHONE or WIRELESS APPARATUS or SYSTEMS. The award for the year 1926 is governed by the following conditions:—

1. The Award will be restricted to employees of the British Post Office.
2. Applications for the Award should be made between 1st January and 31st March, 1927, and such applications should refer to improvements made, or suggested, during the twelve months ending 31st December, 1926.

   Attention is drawn to the fact that recipients of Awards *via* the Post Office Awards Scheme in respect to any improvement in telegraph, telephone or wireless apparatus or systems are eligible to apply for the Booth-Baudot Award in respect thereto.
3. At the discretion of the Council of the Institution of Post Office Electrical Engineers the Award may be withheld if, in the opinion of the adjudicators appointed by the Council, after full consideration of the applications received, no reward is warranted.
4. Applications for the Award, accompanied by full details of the improvement, should be addressed to the Secretary, The Institution of Post Office Electrical Engineers, G.P.O. (Alder House), London, E.C.1.

R. V. HANSFORD,
Secretary.

CENTRAL LIBRARY.

The following books have been added to the Central Library. Applications for the loan of same, should be addressed to the Librarian, Institution of P.O. Electrical Engineers, Alder House.

No.	*Title.*	*Author.*
814	Telephone Communication	C. A. Wright and A. F. Puchstein.
815	Phases of Modern Science	A. and F. Denny.
816	Alternating Currents	A. T. Dover.
817	Prize Essays. 1925	
818	Structure of the Atom	E. N. C. Andrade.
819	Telephone Communication Systems	R. G. Klœffler.
820	The Thermionic Vacuum Tube and its Application	H. J. Van der Bijl.
821	J.P. Transformer Book	S. Austin Stigant and H. Morgan Lacey.
822	Electrical Insulating Materials	A. Monkhouse.
823	Junior Technical Electricity	R. W. Hutchinson.
824	Radio Frequency Measurements	E. B. Moullin.
825	Broadcast Reception	J. L. Pritchard.
826	Fifty Years of Electricity	J. A. Fleming.

1927
Let
HENLEY CABLES
CARRY THE CURRENT
That is a good slogan-and it is good policy too
W. T. Henley's Telegraph Works Company, Limited,
Holborn Viaduct, London, E.C.1.
Telephone City: 2271.
Manufacturers of Dry Core Cables, Aerial Cables, and all kinds of insulated and uninsulated conductors.
925

INDEX TO ADVERTISERS.

	PAGE
Automatic Telephone Mfg. Co., Ltd.	iii
British L.M. Ericsson Mfg. Co., Ltd.	v
Creed & Co., Ltd.	viii and ix
Henley's, W. T., Telegraph Works Co., Ltd. ...	xi
Johnson & Phillips, Ltd.	xviii
London Electric Wire Co. & Smiths, Ltd.	ii
Peel-Conner Telephone Works, Ltd.	xvii
Pitman & Sons, Ltd.	ii
Printed Papers	xv
Siemens Bros. & Co., Ltd.	vi and vii
Smith, Frederick, & Co.	xiv
Standard Telephones and Cables, Ltd.	x
Sterling Telephone and Electric Co., Ltd.	xvi
Telephony Publishing Corp.	xii
The Electrical Review, Ltd.	iv and xii
Tungstone Accumulator Co., Ltd.	xiii
Zeva Elektricitats AKT. GES.	xiv

THE ELECTRICAL REVIEW.

To the progressive Post Office Electrical Engineer the "REVIEW" offers the best means of keeping abreast with modern developments, not only in his own section of the industry, but also in every sphere in which electricity is employed both here and abroad.

Price 6d. weekly from all newsagents,
or 8d. post free.

THE ELECTRICAL REVIEW, 4, Ludgate Hill, London, E.C.4.

The Engineering talent

all over the world reads TELEPHONY because it helps them keep abreast of the important developments in the telephone industry.

Telephony.
THE AMERICAN TELEPHONE JOURNAL

has been the leading journal in its field for 25 years—a quarter of a century of valued service to its eaders. Subscription price (foreign, including postage) $5.00. Issued weekly.

Address: S. Rentell & Co., Ltd., 36, Maiden Lane, Strand London, W.C., 2, for sample copy of TELEPHONY.

TELEPHONY PUBLISHING CORP., 606, S. Dearborn St., Chicago. Ill., U.S.A.

THE ONLY ACCUMULATOR IN THE WORLD WITH PLATE-GRIDS MADE OF PURE LEAD

with the Plate Grids Die Cast and Pasted entirely by machinery. Without Wood Separators or Celluloid, eliminating internal resistance and heat which shortens the life of other makes of plates, and creating constant trouble.

TUNGSTONE
Pure Lead Grid
Accumulator

ROBUST Machine-made Plates permit charge and Discharge at Continuous High Rates with Safety. No possibilities of the Plates Buckling or short-circuiting in service. No Fire or Explosion Risks when Charging above Normal Rates. A Tungstone Battery is not fully charged unless the Acid shows fully 1300 Sp.G. Tungstone Robust Machine Made Plates are in best condition when always kept fully charged.

VERY IMPORTANT ADVICE TO MOTORISTS.

Arrange for Car Dynamo output to be permanently increased so that at a car speed of 20 miles per hour the continuous charging rate is as follows, viz.:

40 a.h. Battery minimum charging rate is 8 amps.
50 a.h. „ „ „ „ 10 amps.
75 a.h. „ „ „ „ 15 amps.

Tungstone Machine Made and Pasted Plates are Heavier and Stronger than any other make of Plate, and therefore can be continuously charged at these higher rates than any other make of battery.

Tungstone Plate Grids being made of Pure Lead, and the Paste of Pure Lead Oxides, ensures exceptional storage capacity and quick discharges, therefore provision is made to give continuous, ample and generous power for Self-starting without cranking.
Follow these instructions and you permanently get the full benefits of the originality of Tungstone Design and Manufacture of a Pure Lead Plate and Grid giving exceptional Strength, Storage, Dependability, Reliability, Security, and Safety.

CHARGING HIGH TENSION AT 12-16 VOLTS POTENTIAL.

All H.T. Tungstone Accumulators are fitted with a Patent Equipment whereby each series of 12 Volts can be coupled in parallel so that these H.T. Batteries of whatever voltage can be charged at local Garages and Charging Stations on a 12-16 Volt Low Tension Charging Plant.
Charging Terminals are provided on the front of the Cabinet arranged in two rows, the top row being Positive and the bottom row Negative. When in use these charging terminals are connected in pairs so that all cells are in series.

☞ **Apply for copy, sent post free, Illustrated Booklet—**
"Photography tells the Story of the Tungstone Accumulator."

Please address all communications to the Distributors' Offices and Showrooms:
TUNGSTONE ACCUMULATOR CO., LTD.,
3, ST. BRIDE'S HOUSE, SALISBURY SQ., FLEET ST., LONDON, E.C.4
Telegrams: "Typify, Fleet, London." Telephone: Central 8157 (4 lines).

SOLD BY ALL DEALERS. T.24

Series of Patent Designs and Trade Mark Issued or Applied for in the Chief Countries of the World.

FREDERICK SMITH & CO.,

Incorporated in

The London Electric Wire Co. & Smiths, Ltd.,

ANACONDA WORKS, SALFORD, MANCHESTER.

HARD DRAWN H.C. COPPER LINE WIRE.

Special Tinned H.C. Copper Wire.

COPPER TAPES AND BINDERS FOR LINE WIRE.

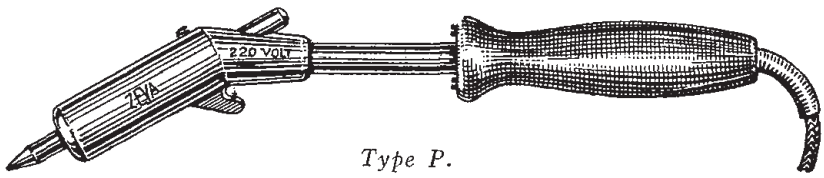
COPPER TROLLEY WIRE

SPECIAL NON-FOULING SECTIONS.

SILICIUM BRONZE WIRE

"C" Quality for Telephone Lines, &c.

Special Electric "Zeva," SOLDERING IRON for Telegraph and Telephone purposes.



Type P.

Electric "Zeva" Soldering Irons have no need of spare-elements. As a consequence the costs of maintenance are nil.

ZEVA ELEKTRICITATS AKT. GES.

CASSEL.

Telegraphic Address: "ZEVA."

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

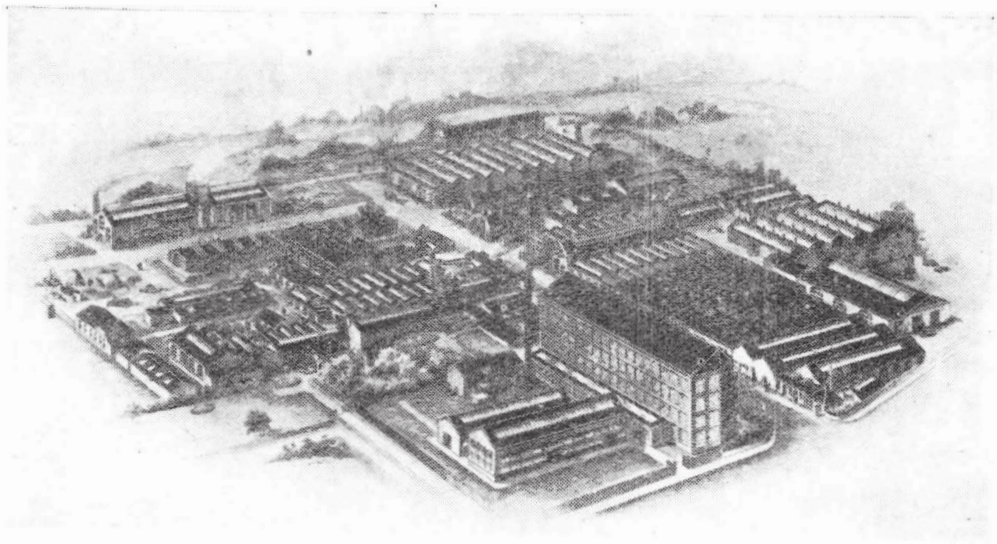
PRINTED PAPERS.

The following papers, contributed to the proceedings of the Institution, have been printed by authority of the Council and may be obtained from

"The LIBRARIAN,
The Institution of Post Office Electrical Engineers,
G.P.O. WEST, LONDON, E.C."

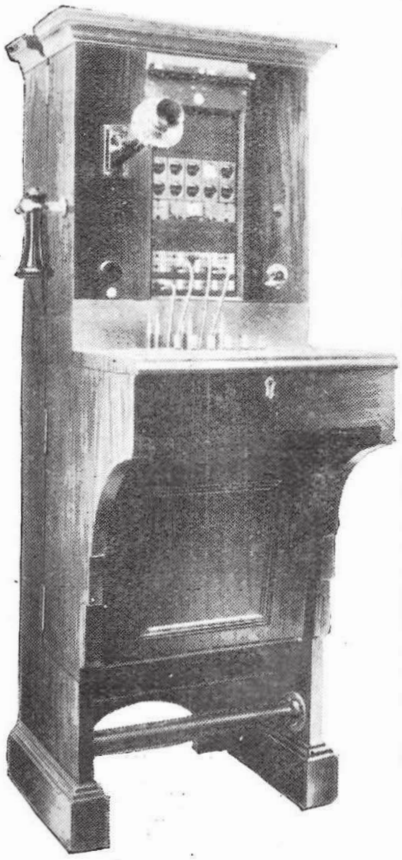
No. 61. "WIRELESS CALL DEVICES."—L. B. TURNER ... ... 6d.
No. 64. "AN ADDRESS ON 'TELEPHONES.'"—SIR WILLIAM SLINGO ... 6d.
No. 65. "BUILDING MATERIALS: PROPERTIES, MANUFACTURE, AND USE OF."—L. TANNER... ... ... 6d.
No. 67. "MULTIPLE WAY DUCT WORK."—D. C. SAVORY ... ... 6d.
No. 70.† "TELEPHONOMETRY."—B. S. COHEN, A.M.I.E.E. ... ... 6d.
No. 72. "THE WESTERN ELECTRIC COMPANY'S AUTOMATIC TELEPHONE SYSTEM."—B. O. ANSON ... ... 1s.
No. 74. "THE ELECTRICAL PHYSICS OF THE ATMOSPHERE."—J. E. TAYLOR, M.I.E.E. 9d
No. 75.† "TELEPHONE REPEATERS."—A. B. HART ... ... 9d.
No. 79. "RECENT DEVELOPMENTS IN UNDERGROUND CONSTRUCTION."—A. O. GIBBON ... ... 9d.
No. 80. "SOME NOTES AND VIEWS UPON TELEPHONE FITTING WORK."—A. C. GREENING, A.M.I.E.E. ... ... 1s.
No. 81. "TELEGRAPH AND TELEPHONE ENGINEERING IN THE UNITED STATES."—SIR WILLIAM NOBLE, M.I.E.E. 1/6
No. 82. "SECONDARY CELLS."—R. G. DE WARDT, A.M.I.E.E. ... ... 1s.
No. 83.† "FOUR-WIRE TELEPHONIC REPEATER SYSTEMS." — C. ROBINSON, B.A., A.M.I.E.E., and R. M. CHAMNEY, B.Sc., Assoc.M.Inst.C.E. ... ... 9d.
No. 84. "THE RELAY SYSTEM OF AUTOMATIC SWITCHING."—H. W. DIPPLE, A.M.I.E.E. 1/3
No. 85.† "THE INFLUENCE OF TRAFFIC ON AUTOMATIC EXCHANGE DESIGN."—G. F. O'DELL, B.Sc., A.K.C., M.I.E.E. 1/6
No. 86. "SOME EXPERIMENTS ON CARRIER CURRENT TELEPHONY."—C. A. TAYLOR, B.Sc., and R. BRADFIELD, B.A., Assoc.M.Inst.C.E. ... ... 6d.
No. 87. "CONCRETE WORK AND REINFORCEMENT."—B. J. BEASLEY 6d.
No. 89.† "CORROSION OF LEAD COVERED CABLES BY ELECTROLYTIC ACTION."—S. C. BARTHOLOMEW, M.I.E.E. 1/3
No. 90.† "AUTOMATIC TELEPHONY IN MULTI-OFFICE AREAS."—G. F. O'DELL, B.Sc., A.K.C. ... ... 1s.
No. 91. "THE CENTRALISATION OF CORD REPAIRS." — G. F. BELLWOOD, A.M.I.E.E. ... ... 9d.
No. 92. "TELEPHONE METERS AND COIN COLLECTING BOXES."—W. CRUICKSHANK and F. MCCLARENCE ... ... 1s.
No. 97.† "THE ECONOMICAL PROVISION OF PLANT FOR TELEPHONE DEVELOPMENT." — G. H. A. WILDGOOSE, A.M.I.E.E., and A. J. PRATT, A.M.I.E.E. ... ... 9d.
No. 98. "MAINTENANCE PRECISION TESTING OF MAIN TRUNK CABLES."—B. LISTER ... ... 1s.
No. 99.† "RECENT RESEARCH WORK ON TELEPHONE REPEATERS." C. ROBINSON, B.A., A.M.I.E.E., and R. M. CHAMNEY, B.Sc., Assoc.M.I.C.E. 1/3
No. 100.† "SIEMENS No. 16 AUTOMATIC EQUIPMENT."—CHAS. W. BROWN, A.M.I.E.E. 1/3
No. 101.† "TELEPHONE TRANSMISSION."—J. E. STATTERS 1/3
No. 102. "THE LAW OF CONTROL IN RELATION TO POST OFFICE ENGINEERING CONTRACTS."—F. JOHNSTON, A.C.I.S. ... 6d
No. 103. "SOME FUNDAMENTALS OF AUTOMATIC SWITCHING METHODS IN MULTI-EXCHANGE SYSTEMS."—H. H. HARRISON, M.I.E.E. 9d
No. 104. "CABLE TESTING."—E. S. RITTER, A.M.I.E.E. 1/3

† The Council have awarded Institution Medals for these papers



Sterling

TELEPHONE AND ELECTRIC CO., LTD.



P.B.X. of 5 Exchange lines, 10 extensions and 5 connecting circuits. The cabinet is divided; the front portion being arranged to swing out for inspection purposes.

Contractors to the Admiralty, War Office, India Office, Air Ministry, Postmaster-General and Foreign and Overseas Governments.

OUR Dagenham Works, erected in 1900, and covering an area of 12½ acres, have recently been largely extended, enabling us to quote early deliveries for telephone switchboards and apparatus. We devoted particular attention to the production of P.B.X. switchboards of all types and of outstanding quality. Our ability to meet exacting specifications at competitive prices is evidenced by the recent receipt of an order for 2,300 switchboards from the Government of Australia. We have specialised in the design and finish of P.B.X. switchboards for use in tropical countries.

We are also pioneers in all types of telephones for domestic and commercial purposes, hotel service indicators, mining telephones, blasting machines, field telephones, &c.

Write for copy of Booklet No. 16.

THE STERLING TELEPHONE & ELECTRIC CO., Ltd.
Dagenham, Essex, England.

STERLING LONDON REG^D TRADE MARK

Telephone Apparatus and Exchanges

From a Tag to the Largest Installations

PEEL-CONNER TELEPHONE WORKS can meet all telephone requirements whether for MANUAL or AUTOMATIC TYPE EQUIPMENTS. The factory at Coventry was specially built for the business of telephone manufacturing upon the most up-to-date lines. A large engineering and research staff is constantly employed upon the work of the present and the needs of the future. Be your wants large or small they will meet with equally earnest attention by the PEEL-CONNER Organisation.

Communicate your requirements to

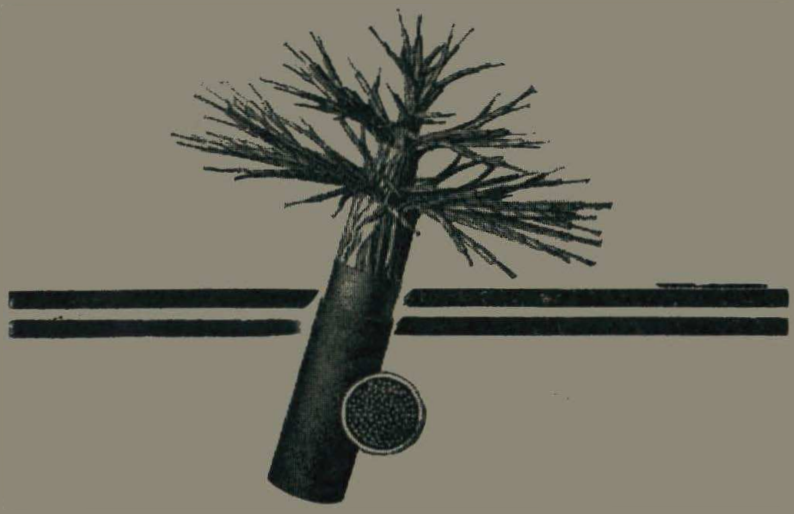
PEEL-CONNER TELEPHONE WORKS

(Proprietors—The General Electric Co., Ltd.)

COVENTRY, ENGLAND.

HEAD OFFICE AND WORKS:
STOKE, COVENTRY.
Telephone: COVENTRY 1310.
Telegrams:
'SPRINGJACK," COVENTRY.

LONDON OFFICE:
MAGNET HOUSE,
KINGSWAY, W.C.2.
Telephone: REGENT 7050.
Telegrams:
'Peelcontel, Westcent, London."



Where the Cables come from

J. & P. Cables are extensively used in the National Telephone Service—and in constantly and consistantly increasing quantities.

And is it so surprising that our business in this direction, both at home and abroad, should have developed so rapidly, when one considers that into every foot of Trunk Telephone Cable that we manufacture, is built the concentrated experience of half a century?

This accounts for that "little more" in quality which means so much in service, and inspires, too, that "little more" in service which adds so much to quality.

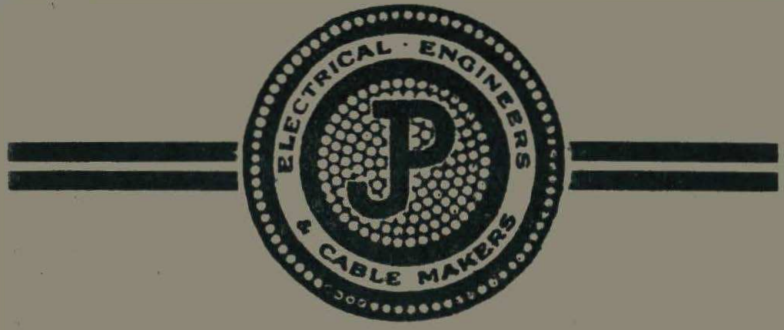
Literature on the above subject gladly on request.

JOHNSON & PHILLIPS, Ltd

Specialists in the Transmission, Transformation and Control of Electricity.

Charlton, London, S.E. 7

Branches in London (City), Birmingham, Bristol, Cardiff, Glasgow, Liverpool, Manchester, Newcastle-on-Tyne, Portsmouth, Southampton, and Belfast.



Printed by Birch & Whittington, Epsom, and
Published by The Electrical Review, Limited at 4 Ludgate Hill London, E.C.